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SUPERABRASIVE INDUSTRY REVIEW

Featuring Grinding and Machining Advancements

THIS ISSUE

IDA 2012 Annual Meeting

Development of New Grades "High Content cBN" for Ferrous Powder Metal Finishing

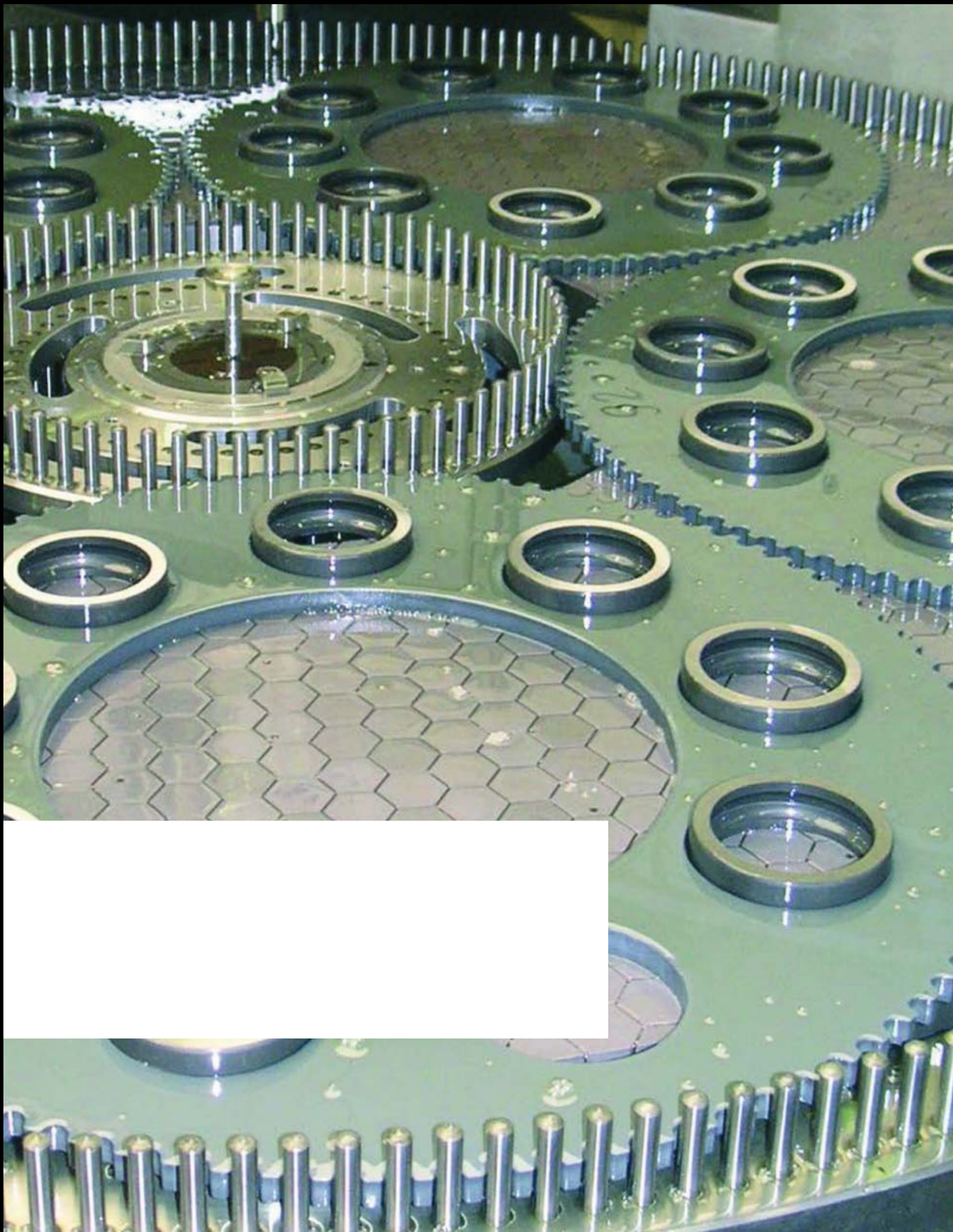
Calendar of Events

News & Notes

Industrial Diamond Association of America Member Companies

Cutting Tool Material Requirements for the Airframe Industry

Finegrinding Replaces Lapping



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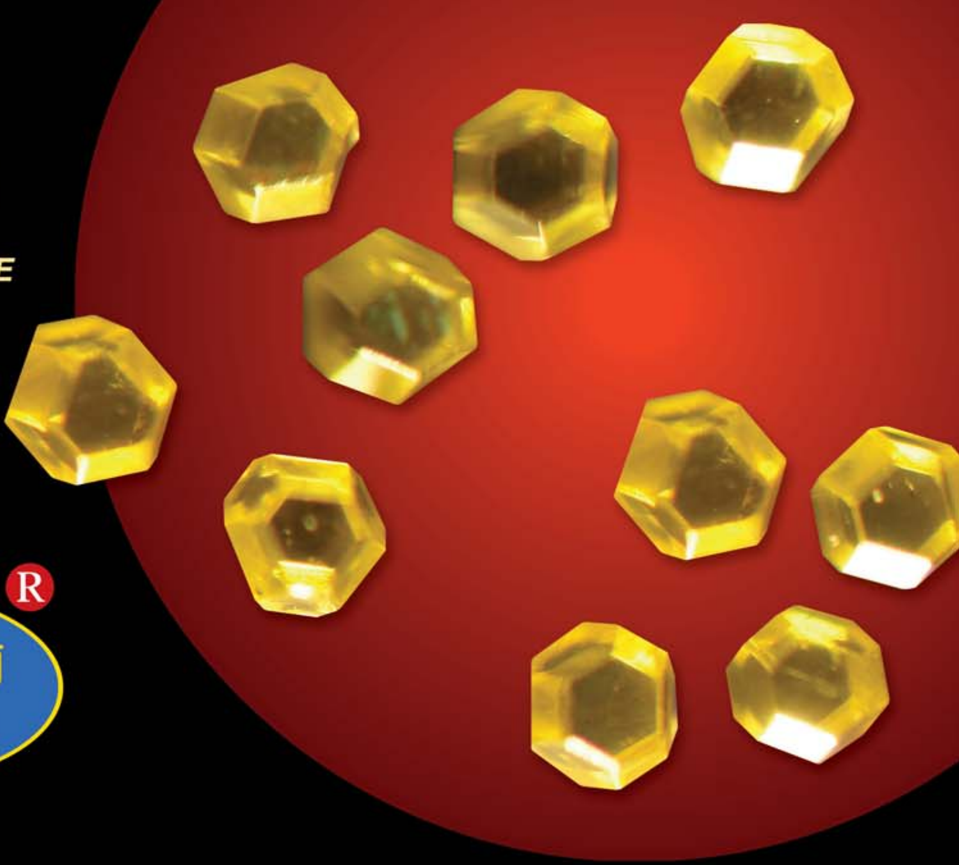

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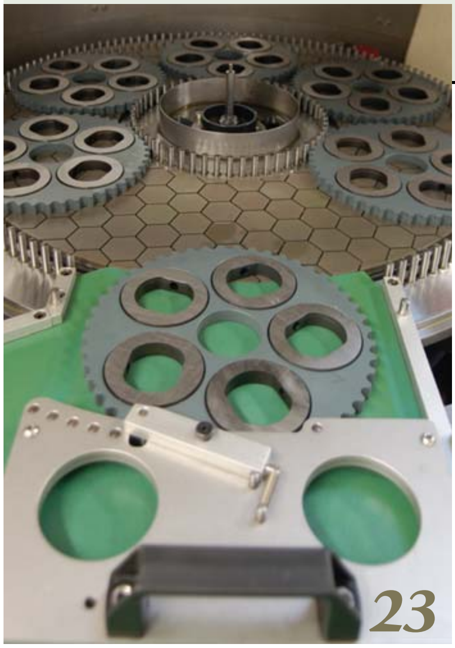

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COVER PHOTO

Finegrinding of Bearing Rings courtesy of Winterthur Technology Group / Wendt GmbH-Germany

FINER POINTS is the longest running publication devoted exclusively to the understanding, selection and application of diamond, cubic boron nitride and related materials. It is edited for recipients who are involved in some way with these "superabrasives", either as providers of the materials, producers of products containing the materials or users of these products (e.g., grinding wheels, dressing tools, drill bits, saw blades, sawing wires, cutting tools, polishing compounds, CVD film products, etc.).

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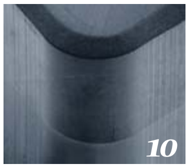

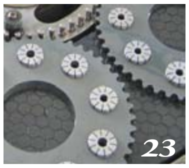

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A Finer Point of View…

For my final Editorial as President of the Industrial Diamond Association of America (IDA), I would like to thank each member of the Board of Directors (BOD), Terry and Kathy Kane, and several IDA members for their diligent efforts in attempting to achieve a very aggressive set of goals and objectives that, if successful, should take the IDA on a path for the next ten years of successfully representing the best interests of each IDA member.

The Board of Directors, in the interest of achieving our goals in an efficient manner, decided to delegate the "heavy lifting" to several committees:

- ***Strategic Planning*** – Steve Griffin and Board of Directors
- ***INTERTECH Planning*** – Scott Ries and David Spelbrink
- ***Membership*** – Julie Griffin, Troy Heuermann and Philippe van Bogaert
- ***Education*** – Dave Edwards, Mike Mustin, Scott Ries and Steven Kelly
- ***Finer Points Content*** – Lola Gibson, Keith Reckling and Joe Connolly
- ***Internet & Media*** – Aaron Nolan and John Chalvadakis
- ***Trade Association and Organization Affiliation & Partnering*** – Keith Reckling

PRESIDENT
Chris Winkel

These committees have constructed action plans that will start the process of transforming the IDA into an association that will not only compete, but also prosper into the future and adapt to the changing needs of its members. The key to ensuring that these committees are successful is participation from IDA member companies. These committees have already seen early dividends with new Finer Points designs, a new Finer Points website, an industry wide Finer points survey, social media development, a renewed focus for INTERTECH programs, the start of new designs for the IDA Website, energized education efforts, interaction with other trade associations and many other positive results. As I have mentioned over the past few issues, the global superabrasives landscape is changing more rapidly than ever before. We, as an association must adapt to succeed and provide the benefits that each member not only requires, but deserves. The shift of the manufacturing of 90% of the world's superabrasive raw materials over the past decade to China may require end-users to assess how they evaluate the future of their respective business models. One of the main ideas resulting from the committee meetings is to partner with other US based organizations that share the IDA's interests in growing superabrasive products manufacturing in the US along with remaining competitive in the global manufacturing marketplace. The Industrial Diamond Association of America had to reinvent itself to be viable in this new global marketplace. Continuing to be successful is the ongoing challenge for each member of the IDA. I would like to thank each of the members of the IDA for allowing me to serve them over the past 12 months and with your help, I look forward to achieving the goals and objectives set forth by this Board of Directors!

With best regards,

Chris Winkel, President
Industrial Diamond Association of America

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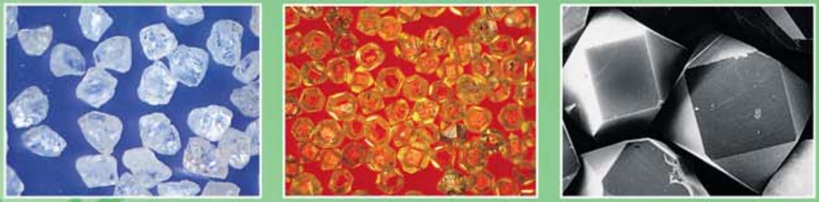

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TERRY KANE, Editor

Everything old is new again!

One of the great things about the Industrial Diamond Association (IDA) is the continuity we have kept through the years and ties we have to our past. Many of our past presidents are still in the organization and I always enjoy receiving calls from our long-time members to talk about the days gone by ... Last winter we held a Board meeting down in Florida and we were honored to have Miles Portman our past president from 1992 sit in the meeting and give his input and viewpoint of the new and innovative programs now going on in the IDA. A few days later I asked Miles what he thought about our discussions and direction of the Association compared to when he was president 20 years ago… Miles sent me the following email and he graciously gave me permission to share this with our readers.

"Terry, in 1992 when I was president of the IDA, the pace was much slower, my year initiated company statistic reporting and in that year we also brought out a new standard for sizing of mesh and micron. Back then GE and DeBeers were key players in the Association and Chinese synthetics were just beginning to come on to the marketplace. There was at that time no thought of what is now a regular IDA INTERTECH, where domestic as well as foreign companies make their presentations to hundreds in the Superabrasive industry. We did have at our annual meeting a technical 'session' where one of our member companies made technical presentations. In my day there was also an economist with a forecast of next year's business prospects ... Times have changed from the 80's and early 90's to present day IDA meetings. I remember going to sites in the Carolinas ... someone had to do it ... to check out the accommodations and more importantly the golfing facilities! Golf and tennis events in the old days took up the recreational part of the program and it was the outside activities that attracted a good portion of the membership to attend those yearly IDA meetings. Most (yearly meetings) were in March and to the many members located in Northern climes it was wonderful to go south or west where there was no snow or cold weather. Many would bring their families and extend their stay a few days to enjoy the sites' facilities and the warm temperatures. The strong voices of the IDA in my time were Wilson Born, Phil Diskin, Butch Peterman and Alan Akerson. We'd always have a sing a-long with Al at the piano and there was a rising star in Dave Edwards, who today holds the record of serving on more IDA boards than anyone, ever has!! Today's IDA is more attuned to the needs of members who want more information on what's going on worldwide in the Superabrasive industry. We are a microcosm of what is the Global Economy, and the goal today is to get everyone, everywhere involved in how Superabrasives can increase their productivity and hence their bottom line. Terry, you have a very active and involved Board of Directors and I'm happy to see the IDA expanding in several directions, always a good sign for growth of the organization. All the best, Miles"

As Miles said, in 1992 "the pace was much slower"; there were no text messages, emails, cell phones or Internet. Speed today is the essence of doing business. We always learn from our past to reinvent the present and prepare for the future. Today's new and innovative ideas are tempered with the in-depth experience from our valued members ... Yes, everything old is new again!

1992 IDA President, Miles B. Portman

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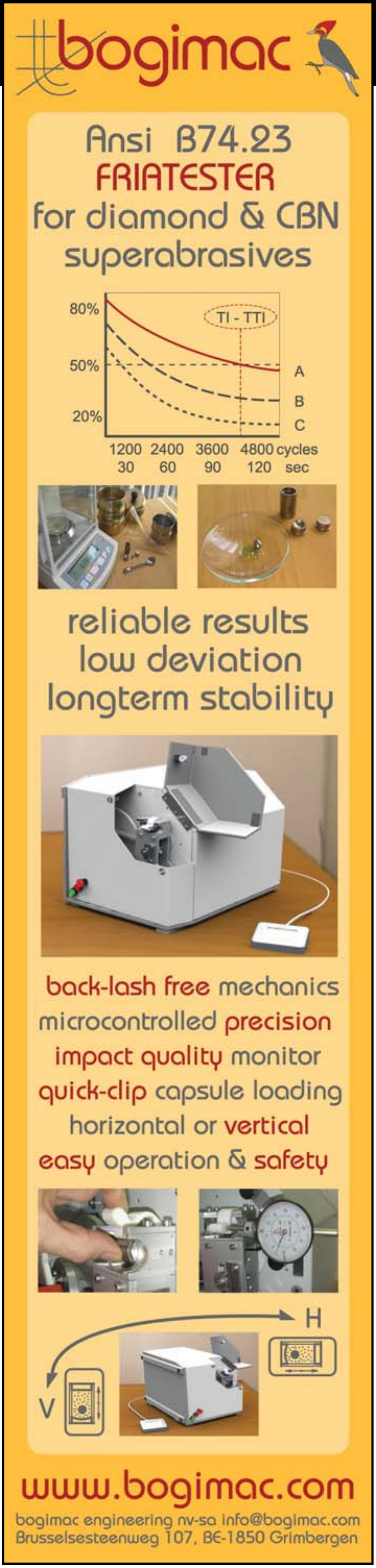

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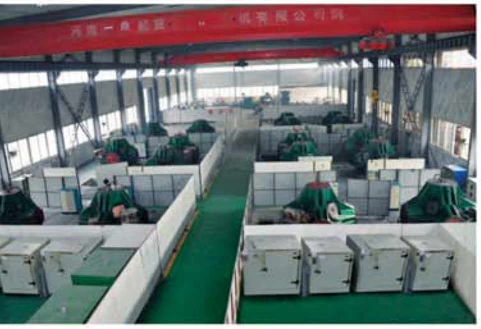
THE FUTURE OF SUPERABRASIVES

Mr. Han Jun, President and CEO of BESCO Superabrasives
Mr. Chris Winkel, President and CEO of WWSA
Mr. John Chalvadakis, Operations Manager of WWSA

- WWSA (Worldwide Superabrasives, LLC) and our joint venture partner, BESCO Superabrasives, proudly announce the expansion of our manufacturing facility in Kaifeng, China.
- WWSA/BESCO, which was founded in 2008, has made a significant investment to increase our plant capacity by over 80% to 60,000 square feet to meet customer demand.
- Included in our expansion is our new superabrasive raw material catalyst production facility—continuing our goal of controlling every part of the superabrasive manufacturing process.
- WWSA/BESCO will produce over 140,000,000 carats of the highest quality resin bond industrial diamond and Cubic Boron Nitride (CBN) in 2012 at our Kaifeng factory.
- WWSA/BESCO will increase the expansion of our manufacturing capacity to no less than 180,000,000 carats by the end of 2013.
- Recent reports indicate that approximately 90% of superabrasive raw materials are manufactured in China—regardless of the name on the label.
- WWSA/BESCO is in a very powerful position for many years into the future as a manufacturer of the highest quality superabrasive raw materials and a provider of world-class technical support, product delivery and customer service.
- IN SUMMARY, WWSA/BESCO will play a significant role in the future of the supply of superabrasive raw materials.



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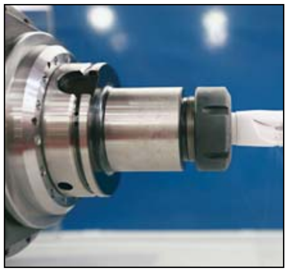
ELEMENT SIX ANNOUNCES A 34% INCREASE IN CONSTRUCTION TOOL LIFE USING ITS WORLD-LEADING HARDZONE™ SYNTHETIC DIAMOND ENCAPSULATION TECHNOLOGY.

This process can be used by tool manufacturers to either extend tool life or increase productivity, and has been designed for high ease of adoption by tool manufacturers. ‘Concrete cutting tests with HardZone™ encapsulation technology showed a 34.6% increase in tool life in comparison with standard mixed particle blades. This is an extremely costeffective ground-breaking technology which will prove attractive to tool manufacturers”, said Dr David Egan, Senior Metallurgist at Element Six. Encapsulation of synthetic diamond is the process of building up metal bond material around the synthetic diamond particle to the extent that the particle is completely enveloped by a sufficient quantity of bond powder to produce a sintered cutting segment. *“We have taken encapsulation to a new level with the addition of HardZone™ technology that incorporates a bond material, with a better wear resistance as a first layer, directly surrounding the synthetic diamond with a subsequently applied outer layer of standard metal bond material. The purpose of this is to improve the tool's wear resistance and enable higher synthetic diamond protrusion, as well as providing the expected uniform synthetic diamond distribution”*, explained Dr Egan. **Visit www.e6.com/encapsulation for more details.**

MAG'S CRYOGENIC MACHINING WINS KING AWARDS GOLD IN THE METALWORKING CATEGORY



Unique throughtool cooling system uses liquid nitrogen to make hard-metal machining more efficient. This multi-patented technology uses liquid nitrogen in a unique through-spindle, through-tool system that cools the cutting edge more efficiently than ever before possible. The results produce much higher cutting speeds for increased metal removal and longer tool life. New Equipment Digest's King Awards competition, named for long-time chief editor Bob King, honors superior industrial product innovation. Winners are selected by the magazine's print and digital readers voting in 11 industrial categories, and there were more than 6,000 votes cast in this year's competition. The key to the efficiency of MAG's cryogenic machining system is its ability to concentrate the cooling effect of liquid nitrogen (-321°F) in the body of the cutting insert. Ideal applications for cryogenic machining involve aggressive metal removal in the hardest workpiece materials, such as titanium, nickel-based alloys and nodular or compacted-graphite iron (CGI). **For more information please visit www.mag-ias.com.**

NEW LASER WELDING MACHINE FOR DRILL BITS FROM DR. FRITSCH

Dr. Fritsch introduced a new centric clamping system. Core drills with diameters 8 mm up to 300 mm can be clamped without changing fixtures. This leads to unique flexibility with drastically reduced set-up times. Thanks to a flying optics on three axes, the diamond segments can be welded fast and directly on the core. The net cycle time is half the previous generation of drill bit welding machines. The welding position is measured 2-dimensionally and then corrected prior to each welding process. This permits an automatic segment side clearance control and the adjustment of tolerances in roundness. There is an automatic axial run-out correction to guarantee a high and constant welding quality. Extensive test series have resulted in a strongly improved welding strength.

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INDUSTRIAL DIAMOND ASSOCIATION

2012 Annual Meeting

May 21, 22 & 23

HYATT REGENCY SCOTTSDALE at GAINEY RANCH

IDA MEMBERS! The 66th Industrial Diamond Association Annual Meeting will be held at the *Hyatt Regency Scottsdale at Gainey Ranch in Scottsdale, Arizona*. This location was selected as an exciting and beautiful venue where we could all get together and do some serious work at improving the IDA and the services we provide our members through new and innovative programs. This year your Board of Directors is organizing a meeting to address both new directions and programs for your IDA as well as current issues in our industry and for all industries in general. The IDA has seen much change over the years in terms of the way we serve and work for our membership. To be viable and continue to be an asset to our members the IDA is embarking on many new approaches to combine established programs with new technologies like social media and on-line information distribution.

It has also become a major issue that manufacturing in the USA has taken a severe hit over the past few years by businesses and technology moving offshore. We have also seen products coming from overseas "dumped" into our industry that harm the very core of our businesses profitability and survival. At this year's Annual Meeting your Board of Directors is addressing both these issues through a number of avenues and is planning to have speakers and workshops to provide our membership with solutions to limit these products from entering the USA and keep US manufacturing at home. Your IDA is implementing plans to interact with other Associations and Organizations with similar interests. Plus we are in contact with Government lobbyists and bureaus that already have addressed many of our concerns.

Mark the dates on your calendars now and make plans to attend this meeting. Nowhere else can you meet and discuss the issues we all have in common with your new Board of Directors, peers, customers and |competitors! Here is your chance to let your voice be heard. This will be ***your "working" meeting*** ... It is paramount that every company in the IDA participates in this year's meeting. Together we can be a force for change! *If you are unable to make it we still hope you contact us with any suggestions or ideas you may wish presented at this meeting that can improve the IDA and its service to you, our valued member.*

PLEASE VIEW UPDATED ANNUAL MEETING INFORMATION POSTED AT: www.superabrasives.org

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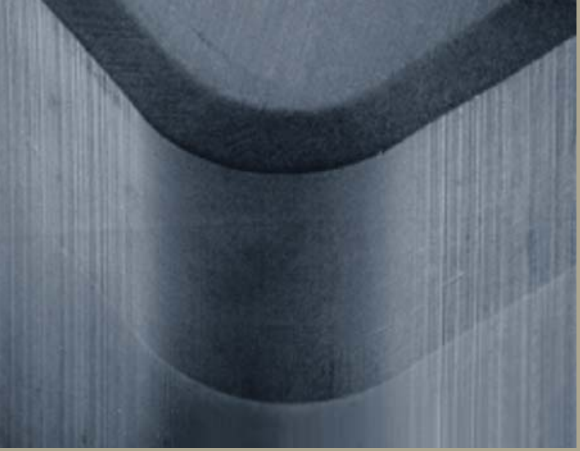


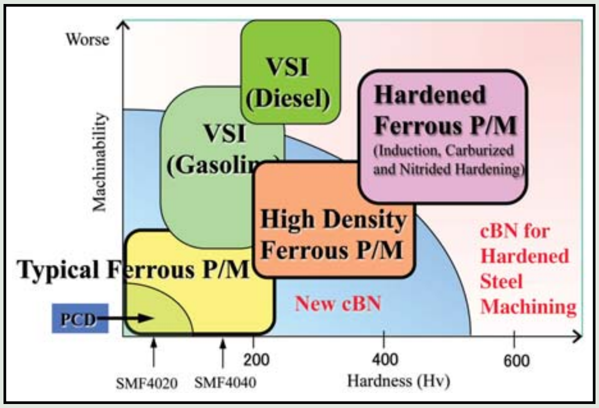
Development of New Grades "High Content cBN" for Ferrous Powder Metal Finishing

Sumitomo Electric Carbide, Inc.
Rich Maton, Engineering Assistant Manager

Cubic boron nitride (cBN) has the highest hardness and thermal conductivity among all materials except for diamond, and also has low reactivity with ferrous materials. We have developed polycrystalline boron nitride (PCBN) by sintering cBN with ceramic binding materials and contributed to shifting the machining method of hardened steel from grinding to cutting. Furthermore we contributed to the productivity improvement and cost reduction in finishing and semi-finishing of ferrous materials such as cast iron and powdered metal with high content PCBN tools. Recently the consumption of ferrous powder metal (PM) in automotive parts is increasing. Ferrous PM parts can be formed into complex and nearing-completion shape with progress of the near net shape technology, and can realize cost reduction and energy saving because of little machining. Ferrous PM also can be designed various material by control the ratio and grain size of added hard particles, sintering density and the method of hardening. However, machinability of ferrous PM parts decreases and conventional cutting tools cannot have enough machining accuracy and tool life. To respond to these needs, our new high content cBN for ferrous PM finishing was developed.

SUBJECTS IN CUTTING OF FERROUS PM

In case of ferrous PM cutting, conventional carbide or cermet cutting tools cannot have enough machining accuracy or cannot achieve enough tool life, therefore the application of PCBN cutting tool is increasing. In recent trends of automotive parts, ferrous PM have greater mechanical properties, as the result, it becomes more hard-cutting, therefore cutting tools are required to have greater wear resistance and breakage resistance.



Especially in finishing of ferrous PM, burr, chipping and retroflexion at edge of workpieces and white turbidity are main problem. To eliminate the burr, chipping and retroflexion at workpiece's edge, brush or barrel finishing is needed after cutting, and the omission or contraction of these processes is required. To suppress burr, chipping and retroflexion at workpiece's edge and white turbidity, maintaining the sharpness of cutting edge is the most important. Partially hardened ferrous PM for strength, which has high hardness, causes tools to wear quickly, and occurs chipping and breakage at cutting edge by interrupted impacts in case of interrupted cutting. Therefore a cBN cutting tool, which has great strength of cutting edge and stability of long tool life, is required.

FEATURES OF NEW HIGH CONTENT CBN

Specifications of new High Content cBN - Table 1 shows the specifications of new high content cBN in comparison with SHM's conventional CBN grade, which has the higher cBN content and finer-graded cBN particles than our conventional, has excellent strength and hardness. Higher cBN content realizes to suppress the abrasive wear by the hard particles in the ferrous PM due to the decrease of the amount of binder in the sintered body. In addition, our new high content cBN, which has the excellent binding force between fine-graded cBN particles, can form sharper cutting edge and maintain the sharpness of cutting edge for a long time.

STRUCTURE OF NEW HIGH CONTENT CBN

The PCBN sintered body of conventional tool is bonded on the carbide substrate over the carbide back metal; however the PCBN sintered body of high content cBN is bonded on the carbide substrate directly (Figure 1). As the result, cBN has thicker PCBN sintered body and can be applied for cutting with large wear. Furthermore, for the decrease of

Subjects in Cutting of Ferrous Powder Metal

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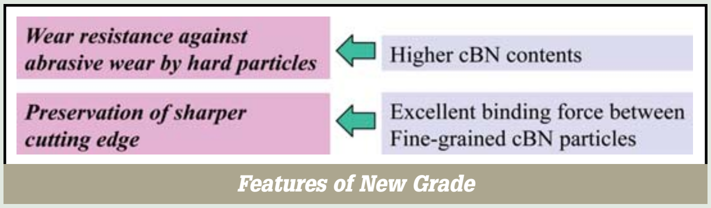

Wear resistance against abrasive wear by hard particles
Higher cBN contents
Preservation of sharper cutting edge
Excellent binding force between Fine-grained cBN particles

Features of New Grade

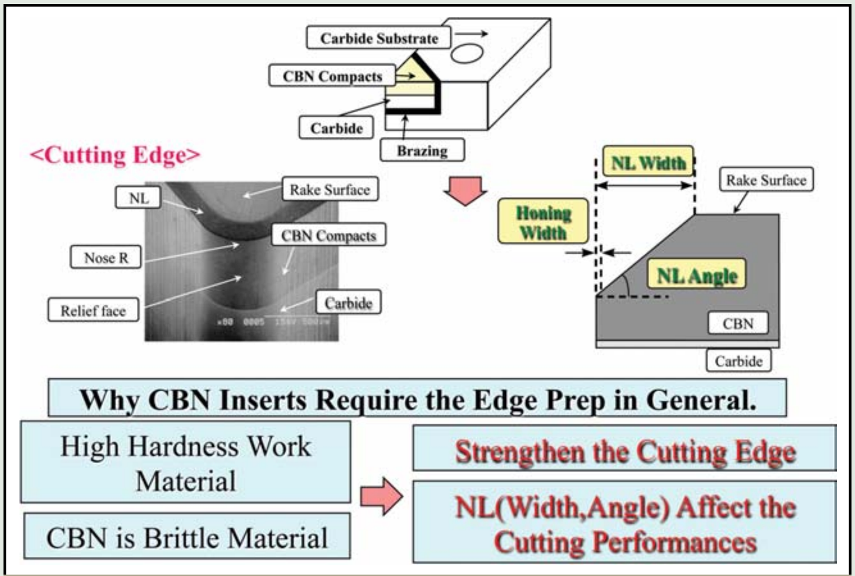
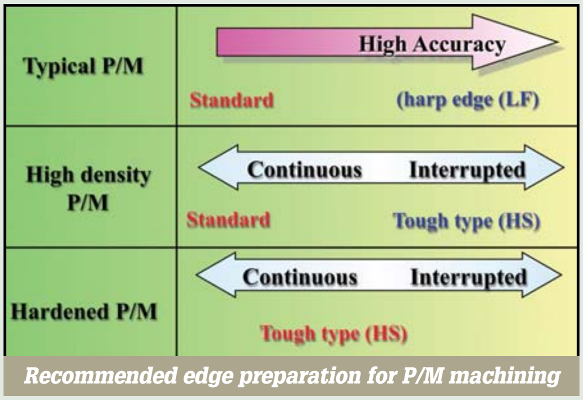


Figure 1: Shows the cross section pictures of cutting edge and edge preparation



Recommended edge preparation for P/M machining

boundary faces between PCBN sintered body and Carbide substrate, stability of the tool is improved, new High Content cBN can use for application of hard cutting of ferrous PM. This new grade has three types of edge preparation, standard-type for general cutting, LF-type with sharp cutting edge and HS-type with tough cutting edge. Each edge preparation supports various ferrous PM machining.

The standard-type, which has an appropriate balance between breakage resistance and sharpness, is the primary recommendation for general ferrous PM finishing. The LFtype is equipped with sharp cutting edges for ferrous PM machining, and can maintain great Recommended edge preparation for P/M machining surface roughness by suppression of burr and white tribulation. The HS-type, which has large chamfer angle and round horning, can suppress the chippings and breakage at cutting edge also in the interrupt cutting of hardened ferrous PM (more than HRC50), and achieves long tool life.

CUTTING PERFORMANCE OF NEW HIGH CONTENT CBN

Figure 2 shows the results of the evaluation for cutting resistance, surface roughness and burr in standard ferrous PM finishing. The workpieces used were SMF4040 which have holes on the face. The LF-type, equipped with sharp cutting edges with no chamfer, has the smallest cutting resistance. HS-type equipped with larger chamfer angle and round honing, so as to have the largest cutting resistance especially back. The standard-type equipped with chamfer angle only, and shows cutting resistance between the LF-type and the HS-type. The surface roughness becomes greater, as the cutting speed becomes faster, and the cutting surface has gloss. The surface roughness machined by each edge preparation becomes good in cutting speed of more than 200 m/min. In cutting speed of 100 m/min., the cutting surface machined by standard-type and HS-type edge have white turbidity and the surface roughness goes bad, however the cutting surface machined by LF-type edge is still good. Furthermore burr at the edge of the hole on the face shows same tendency with surface roughness, burr becomes smaller by using the cutting edge having smaller chamfer angle or faster cutting speed. In case of standard ferrous PM, Standard-type for general use is the primary recommendation, and cutting speed more than 200m/min. is recommended to suppress the white turbidity. If the cutting speed cannot be high due to the size of workpieces, or tool life is not enough by surface roughness or burr, the LF-type with sharp cutting edge is recommended.

CUTTING ON HARDENED FERROUS PM

Figure 3 shows the results of the evaluation for chipping resistance in the machining of hardened PM gear parts (HRC60). The HS-type has excellent strength of cutting edge due to the large chamfer angle of 25 degrees and round horning, and realizes stable and long tool life also in interrupt cutting of hardened ferrous PM. Also in case of hardened ferrous PM, Standard-type for general use is the primary recommendation. If tool life is not enough by chippings or breakages occurred at cutting edge, The HS-type with tough cutting edge is recommended.

MECHANISM OF WHITE TURBIDITY ON FERROUS PM

The mechanism of white turbidity on cutting surface of ferrous PM, is not resolved completely, however it is empirically known that it's suppressed by using sharper cutting edge or faster cutting speed as described in this article. Figure 4 shows results of the evaluation about white turbidity of ferrous PM in perspective of sharpness of cutting edge.

The workpieces used were SMF4040 (HRB70) machined by new high content cBN and our conventional PCBN

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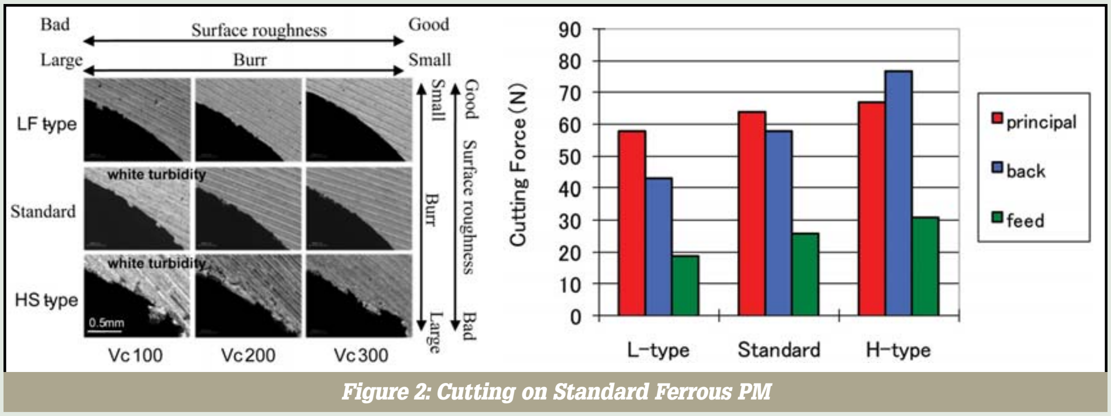


Figure 2: Cutting on Standard Ferrous PM

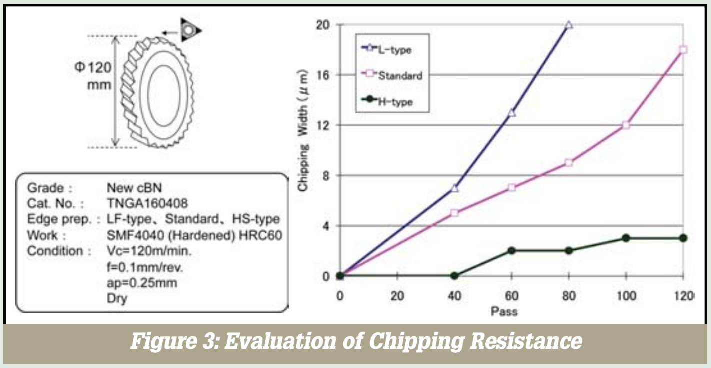
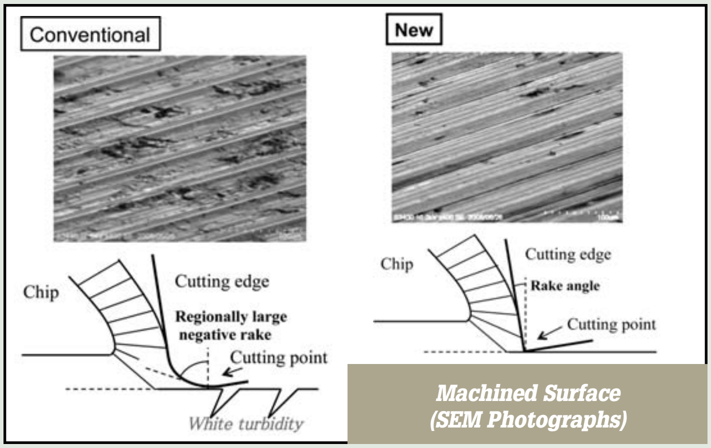


Figure 3: Evaluation of Chipping Resistance

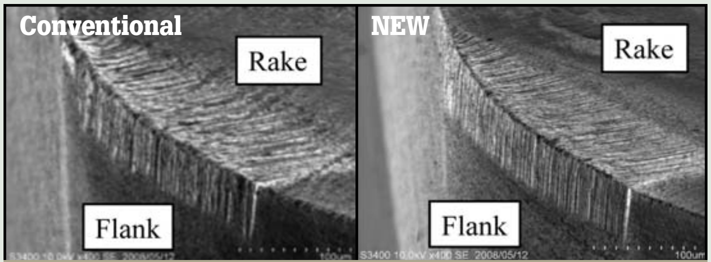
grade. Figure 5 shows the SEM photograph of damaged cutting edge with the same flank wear width (VB = 0.05mm). In the conventional cBN cutting edge, the ridge line has roundness because of the dropout of coarse-grained cBN particles. In the new High Content cBN cutting edge, the ridge line maintains sharpness. By comparison of the cutting surface machined by each damaged cutting edge, the cutting surface machined by conventional cBN had white turbidity; however the cutting surface machined by new high content cBN did not. It is presumed that the white turbidity occurred for reduction of cutting edge's sharpness by the rounded ridge line of cutting edge, where the negative rake angle becomes large. To suppress the white turbidity, it is important that the cutting edge is kept sharp. By using High Content cBN, which can suppress the dropout of cBN particles at cutting edge, the white turbidity is suppressed and high precision cutting and longer tool life can be achieved.

APPLICATION AREA AND EXAMPLE OF NEW HIGH CONTENT CBN

In case of ferrous PM roughing, stability of breakage resistance is important because the burr, chipping and retroflexion at workpiece's edge is eliminated at brush or barrel finishing after cutting. Therefore, we recommend conventional cBN tool, which has high fracture toughness property due to the larger grain-size of cBN particles, in roughing of ferrous PM. On the other hand, new high content is recommended in ferrous PM finishing, because it can maintain the sharpness of the cutting edge foe a long time due to the excellent strength of cutting edge. The new high content cBN exhibited excellent property, for example, in machining of oil pump rotor, variable valve timing-intelligent system (VVT) and plunge finishing. Figure 6 shows the example of the use of new high content cBN cutting tools. In case of standard ferrous PM finishing, new high content cBN showed 1.5 – 2 times longer tool life than conventional cBN cutting tool due to suppression of the burr.



Machined Surface (SEM Photographs)



WHITE TURBIDITY WILL OCCUR DUE TO DULL CUTTING EDGE

Figure 5: SEM Photo of Cutting Edge

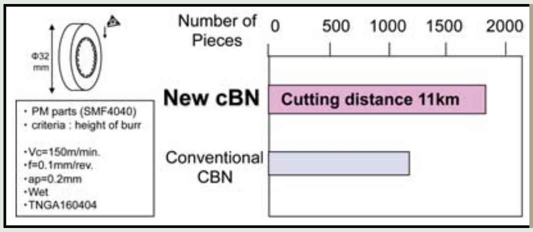


Figure 6: Face Finishing of Ferrous PM Parts

CONCLUSION

By using new High Content cBN, for ferrous PM finishing, burr and white turbidity are suppressed and longer tool life can be achieved in cutting of ferrous powder metal. New high content cBN has the highest strength among our series, and it can be used not only for machining of ferrous PM but also for applications like high-speed cutting of cast iron, heavy-interrupted machining of hardened steel and hard milling, which are needed tool with high strength, and expansion of application is expected.

NEWS and notes

FINER POINTS MAGAZINE LAUNCHES A NEW WEBSITE WWW.FINERPOINTSMAGAZINE.COM

The new website will include all past issues of Finer Points and a searchable database to call up articles and releases based on topics, materials and products. The website will enable visitors to view and download past issues and feature the latest issue on-line with listed articles from the current issue as well as easy access to advertisers through direct links and banners. A news ticker across the top will alert visitors to breaking news.

WORLDWIDE SUPERABRASIVES, LLC (WWSA) IS PLEASED TO ANNOUNCE THE HIRING OF DAVID SIMPSON, FORMERLY OF SUMITOMO ELECTRIC CARBIDE.

Dave joins a world-class sales team of Chris Winkel, Dan Herzog and John Chalvadakis to add his +15 years of experience of providing the highest quality superabrasive materials to a technologically diverse customer base. Prior to joining WWSA, Dave was the sales manager for Sumitomo Electric Carbide Materials Group, responsible for PCD/PCBN cutting tools, wire die blanks, specialty carbide blanks, ZnSe crystal lenses and single crystal diamond blanks for North and South America. In addition, Dave has spent 10 years on the IDA Board of Directors, serving as president in 2008 along with the Wire Associations Ohio Valley Chapter Board of Directors. Dave earned his BS in Business Systems and Economics Management at Michigan State University.

CINETIC LANDIS CORP. ANNOUNCED THE PROMOTION OF JOHN LEONE AT THE COMPANY'S CONCORD TOWNSHIP, OHIO FACILITY

John Leone has been named Vice President & General Manager of the Consumables Operation of Cinetic Landis Corp., comprised of CITCO Tools and Gardner Abrasives. The operations are part of the Fives Cinetic Division of the global Fives Group of companies headquartered in Paris, France. Mr. Leone, previous Director of Sales & Marketing for CITCO/Gardner, has an extensive background in highly engineered industrial product sales and marketing and has worked with direct sales personnel, independent manufacturer's representatives and distributors worldwide. More information can be found on the company's website at www.fivesgroup.com/tools

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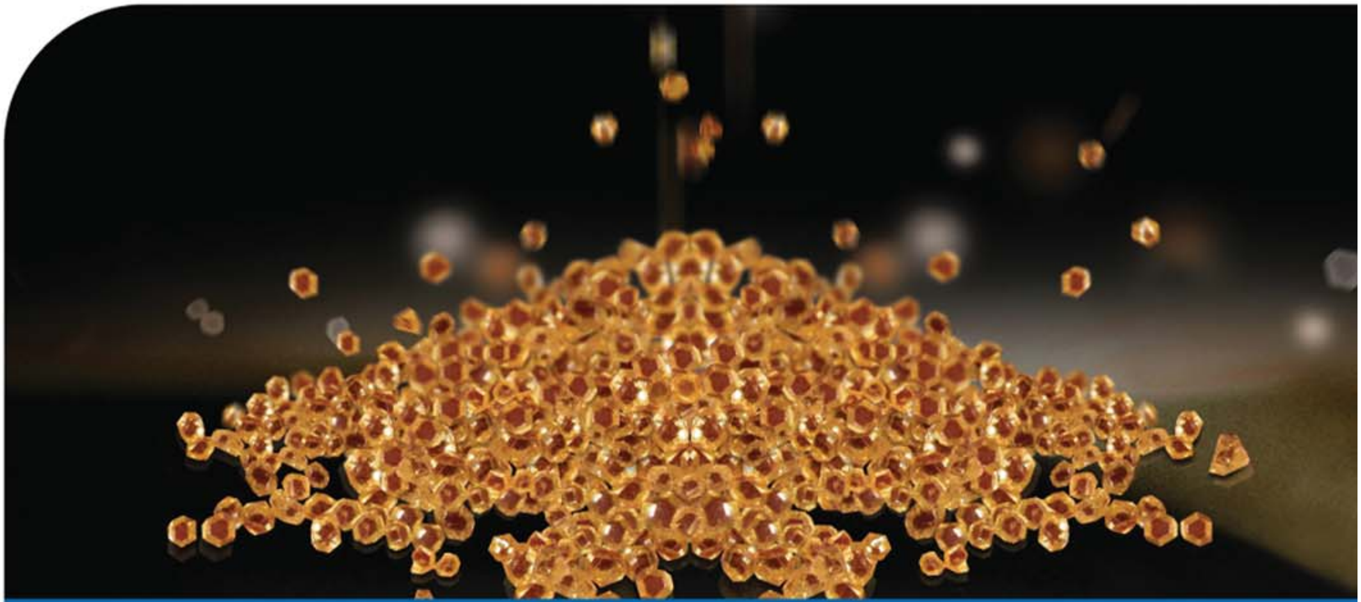

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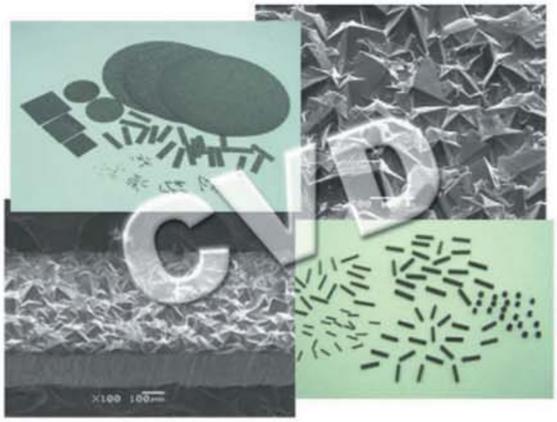

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Cutting Tool Material Requirements for the Airframe Industry

JEFF LANTRIP, Boeing Research & Technology • Renton, Washington, USA

The airframe industry has been undergoing a major change with the increased use of composites in structural applications. This drives the increased use of polycrystalline diamond, CVD diamond coating, and other superhard cutting tool products. However, along with the increased use of composites, there is also an increased use of titanium, and the need to drill holes in stacks containing both materials. This is a very challenging application that requires a cutting tool material that is both very hard and tough. This presentation will outline the requirements for new cutting tool materials for the airframe industry.

INTRODUCTION

The changes in the airframe industry have resulted in several challenges that impact the use of and requirements for cutting tools due to Advanced Materials, Design, Production System and Global Sourcing.

CHALLENGES DUE TO ADVANCED MATERIALS

In order to increase the efficiency of aircraft and reduce the life cycle costs, there has been an increased use of composites and titanium (see Figures 1 and 2), both separately and stacked together. In the newest commercial aircraft, the Boeing 787 and the Airbus A350, the airframes will be mostly composite. In addition, new alloys and combinations of materials are being used to reduce weight and improve the durability and corrosion resistance. This results in reduction in operating cost through increased fuel efficiency and longer structural life. The primary airframe material has been aluminum for many years due to its light weight and reasonably good strength. Since there is a galvanic corrosion issue with contact between graphite composites and aluminum, the structural components attached to graphite composites are generally titanium. These two materials are difficult to drill by themselves, and even more difficult when drilled together in a stack. They have different cutting requirements, not only different drilling parameters, but different requirements for a cutting tool material. For fiber-reinforced composites such as CFRP, drilling is very much similar to drilling wood. Cutting the fibers cleanly is key, especially at the exit, requiring high shear geometry and high cutting speeds. CFRP is also highly abrasive, so a very hard cutting tool material is required; meaning at least carbide, but preferably diamond. Titanium also likes high shear geometry, but at the higher cutting speeds for composites too much heat is generated, resulting in reduced fatigue life of the aircraft component. In addition, titanium has chemical affinity to most cutting tool materials. Thus, for the most part, cobalt high-speed steel and carbide have been the primary cutting tool materials used for titanium. However, these materials do not have the wear resistance to provide extended life in composites. When the cutting edge dulled by the abrasive composites tries to cut the titanium, workhardening occurs, and then tool failure. There have been some promising results machining titanium with polycrystalline diamond (PCD), but greater toughness is desired to resist chipping. Also, in addition to composite and titanium, there may be aluminum or stainless steel in the stack, each of which has their own requirements.

Carbon Fiber Composites Machining Challenges

- Material is very abrasive – results in high wear rates
- Anisotropic properties (due to combination of soft matrix and hard fibers in varying orientations) – thus cutting tool sees varying cutting resistance
- Plastic matrix – limits cutting temperature
- Fiber reinforcement – requires sharp cutting edge, high shear geometry and high velocity to be cut cleanly
- Laminate structure – prone to delamination under excessive cutting forces (e.g., high drilling thrust)
- Dust is created instead of chips – requiring vacuum or flood coolant to control

Titanium Machining Challenges

- Low elastic modulus – material pushes away during cutting and “springs back”, thus high clearance angles are required
- Low thermal conductivity – leads to high cutting temperatures (80% of heat generated goes into the tool, compared with 50% for steel)
- High chemically reactivity at higher temperatures – has a tendency to weld to the tool, leading to chipping and tool failure

- Work hardening – especially at very low feed rates
- High strength maintained at elevated temperature
- Segmented chip – creates cyclic forces and fatigue on tool
- Greater susceptibility to surface damage during machining operations – resulting in appreciably lower fatigue life

Ideal Cutting Tool Material

In general, the desirable properties for a cutting tool material are:

- Small grain size to be able to produce a sharp cutting edge
- High hardness, including high hot hardness, to provide excellent abrasive wear resistance
- Good toughness (high TRS & fracture toughness) to maintain sharp cutting edge without chipping/deformation under the dynamic action of the cutting force
- Good thermal conductivity to remove heat from cutting zone
- Thermal stability to maintain integrity under cutting temperatures
- Low chemical affinity or reactivity to workpiece material

The degree to which each of these properties is needed depends on the workpiece material. The difficulty is finding all of these properties in the same material. Generally there is a tradeoff between hardness and toughness, but for the combination of CFRP and titanium, both are needed.

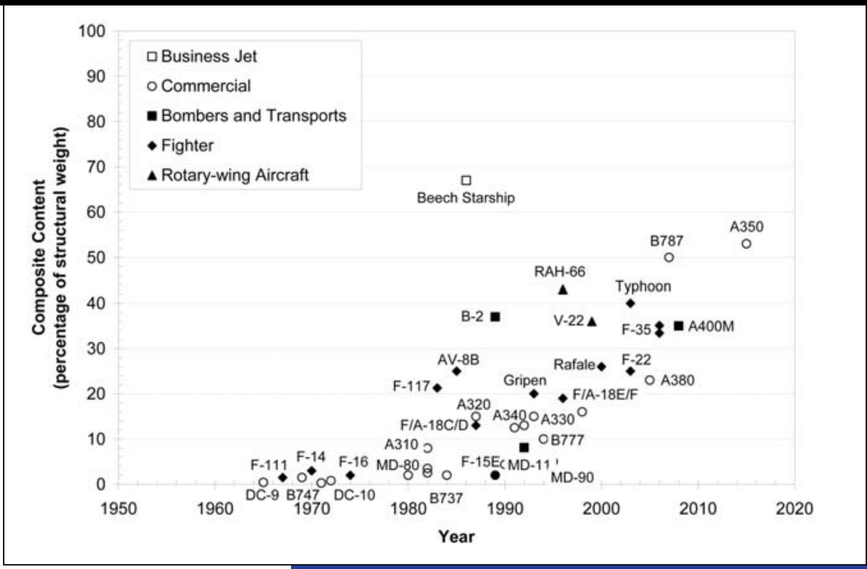


FIGURE 1:
Change in Composite Use in Aircraft

CHALLENGES DUE TO DESIGN

The use of composites facilitates part consolidation through cobonding and cocuring parts into larger assemblies. In metal structure there has been the shift from sheet metal construction to monolithic parts that often have deep pockets and thin walls. This part consolidation results in reducing the number of fasteners, thus the number of holes one needs to drill. However, the majority of fasteners eliminated are those termed "acreage fasteners," large numbers of smaller diameter fasteners that lend themselves to automation. Most of the holes that are left are more difficult holes; larger diameter holes in thicker, multiple material stacks. This results in the need to drill larger diameters and stacks thicker than previously seen in any other aircraft program.

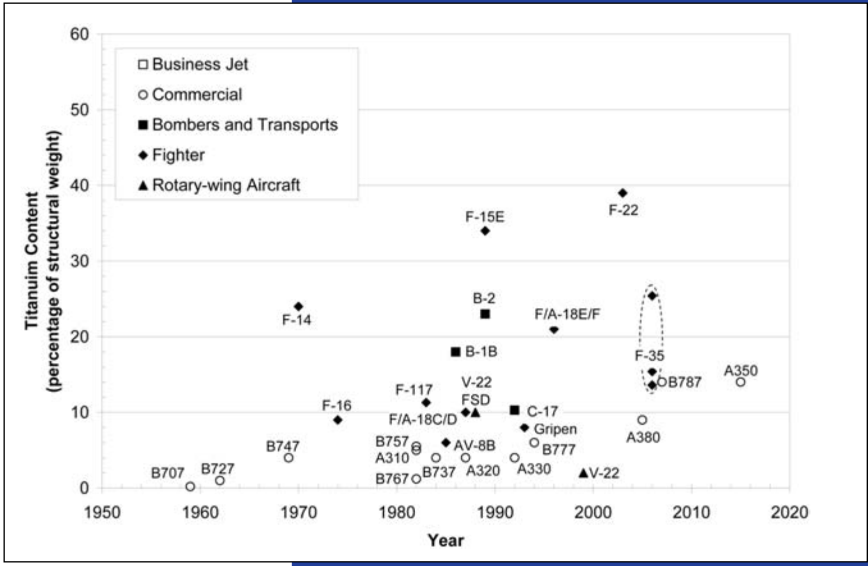


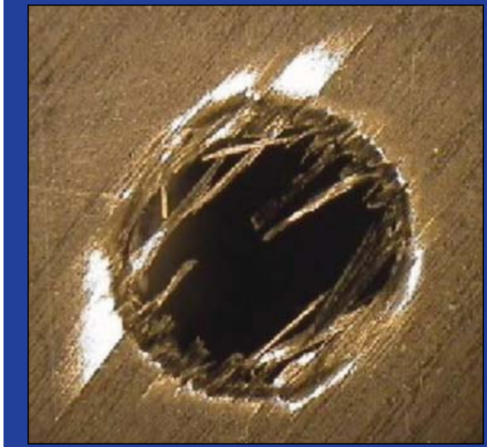
FIGURE 2:
Change in Titanium Use in Aircraft

CHALLENGES DUE TO PRODUCTION SYSTEM

Need For Greater Machining Capacity

The shift from aluminum to titanium and monolithic parts means that airframe manufacture is more machining intensive and there is a need for greater machining capacity. The buy-to-fly ratio (ratio of original material block weight to finished part weight) on average is 8:1, and can be as much as 30:1. That's 8 lbs of titanium chips per pound of finished part. Due to the fact that the metal removal rate for titanium is one-tenth that of aluminum, that means a lot of spindle time cutting chips. Figure 3 shows the improvement in material removal rate for roughing and finishing titanium over time as machining technology improved.

One can see that the titanium machining improvement is leveling out and there is a need for new technology to enable further improvement, improvement which is much needed considering the substantial increase in titanium in aircraft structure, as well as increased use of composites.



Composite Breakout & Fraying at Exit

Assembly Changes

The following changes in aircraft assembly which drives increased performance and quality requirements from drilling process:

Increased drive to reduce flow time and unnecessary steps

- One-shot drilling – drill hole in one step
- One-up assembly – drill and fasten without separating to clean, deburr, etc.

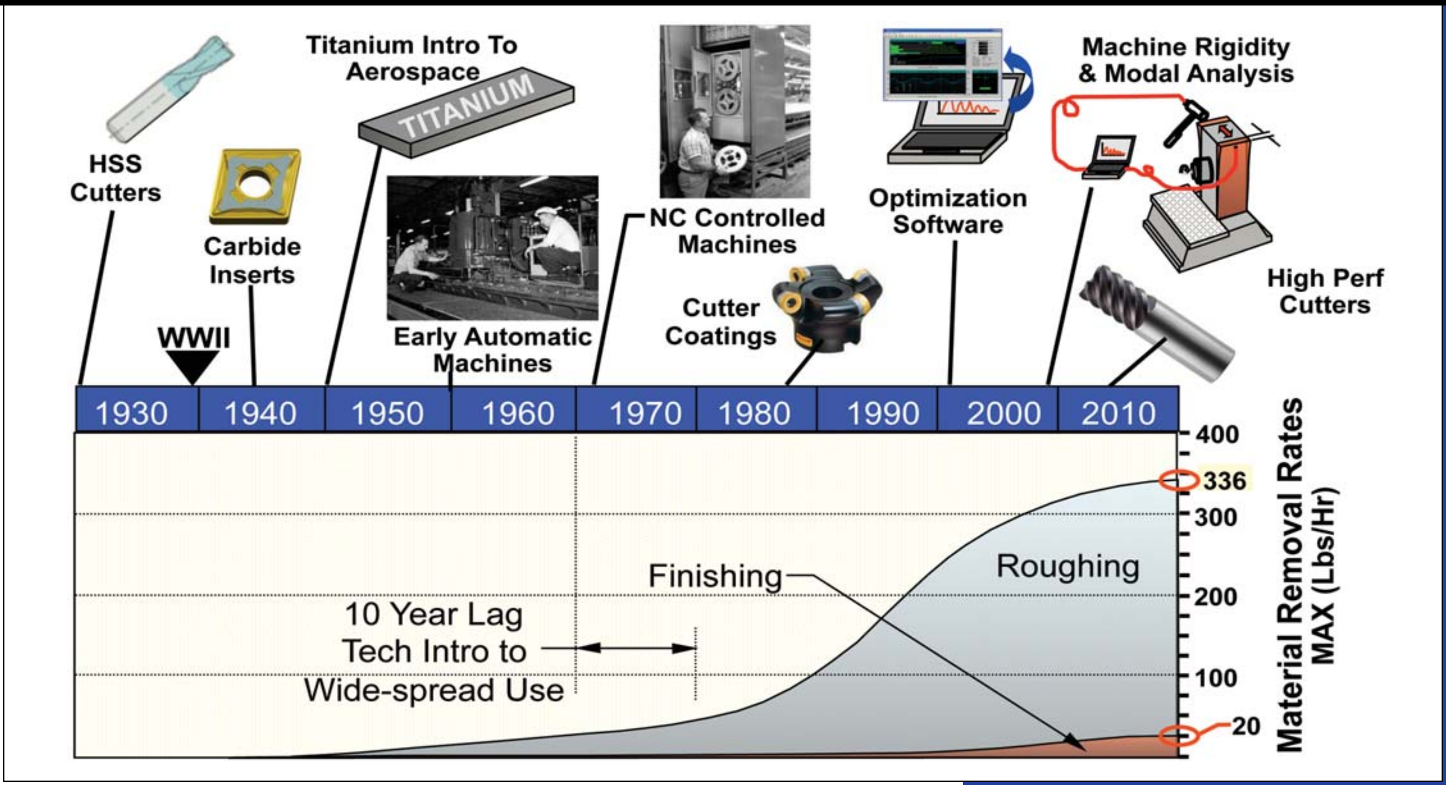


FIGURE 3:
Improvements in Titanium Machining

- Desire to do MQL or dry drilling to reduce cleanup time and avoid interlaminar penetration of cutting fluid
- Results in increased quality requirements from drilling process

Increased use of automation – large-scale and small-scale

- However, pneumatic drill motors are still primarily used in final assembly operations - limited horsepower

Increased use of lean principles

- Moving line, reduce flow time, need for more reliable processes

These items all result in reduced tool life, to the degree that a new cutting tool material is needed to improve cost and productivity. Another thing that drives the need for longer tool life is decreased flow time in final assembly. If one looks at the backlog of orders (Figure 4), one sees why there is a desire to increase the production rates. The goal for the F-35 is to product one plane per day out of final assembly. For comparison, the 737 is at an 8 day flow (down from 22 days in 2000). Part of the ability to achieve that rate on the 787 is due to pushing some of the work upstream, so the pieces arrive prestuffed with aircraft systems, etc., but as noted before, drilling to be done in final assembly is the most challenging.

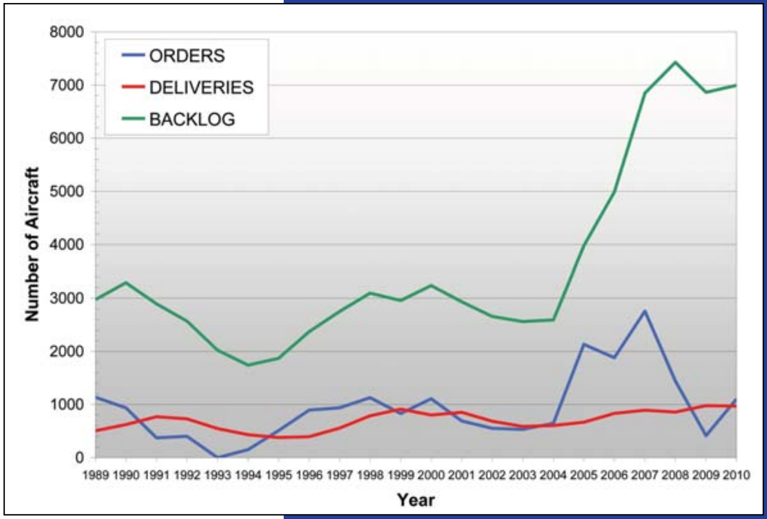


FIGURE 4:
Commercial Aircraft Orders, Deliveries and Backlog (Boeing & Airbus)

CHALLENGES DUE TO GLOBAL SOURCING

Many things drive global sourcing, including offsets to sell planes, risk sharing with suppliers, etc. The challenges that come with that are:

- Often there is a lack of infrastructure (tooling suppliers, regrind houses, etc.) to support the factory.
- Equipment, technology, and technical knowledge not always available.
- Have to work export controls for not only products, but information as well.

CONCLUSION

Considering the number of aircraft that need to be built using an increased amount of composites and titanium and the push for reduced assembly flow time, the opportunities for improvement are great, and thus the opportunities are great and varied, but not unobtainable. ■

Industrial Diamond Association of America, Inc.

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Provide names of principle officers or partners: ______________________________
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How long has your company been engaged in superabrasive/ultra-hard material industry? _______

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- **Establishes Industry Standards**
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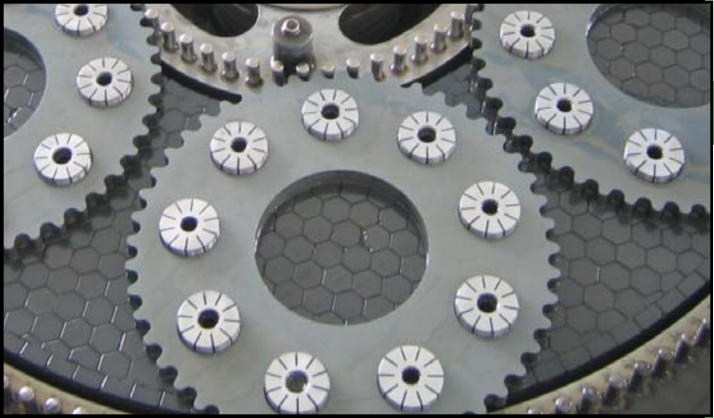
FINEGRINDING REPLACES LAPPING

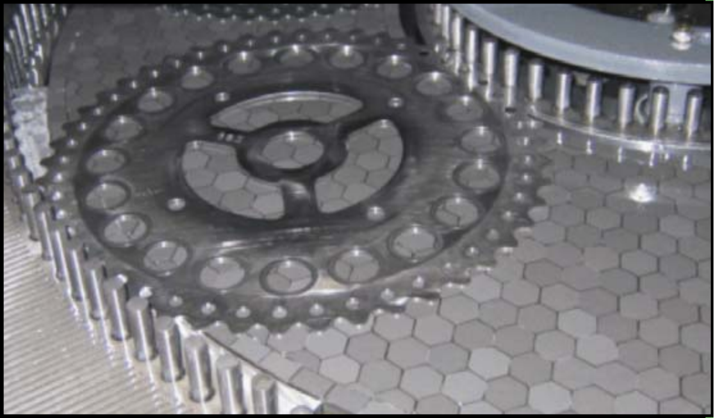
M. Martin, Dr. P. Dennis
Winterthur Technology Group / Wendt GmbH- Germany

Cast Iron Flange

Roller Bearing Rings



Pump Rotors



Shims – Injection Systems

FIGURE 1:
Workpieces on Fine-Grinding Systems (upper wheels removed)

Since many years finegrinding with lapping kinematics is being used to finish high precision workpieces in double side grinding processes. Today small and large batches of hard materials and hardened steel parts can easily be ground on these machines with superabrasive wheels. In industry, through feed face grinding machines are being used to rough grind parts before finishing them on finegrinding machines. Typical market requirements in flatness, parallelism and surface roughness Rz are below 2 µm. Exact for these applications finegrinding has been developed and in the meantime it is a proven process comparable with lapping in respect of surface quality. Finegrinding is even remarkable in respect of its cool grinding and low surface damage. In addition, actual machine developments with more powerful drives and higher speeds allow rough and finish grinding on one machine with identical grinding wheels.

INTRODUCTION

Since the mid-1990s double-sided surface-grinding on machines with lapping kinematics for machining high-precision, plane-parallel workpieces has become a viable alternative to conventional lapping. This machining process, also known as fine-grinding or flat-honing, is used to produce precise planeparallel functional surfaces on generally flat workpieces. Typical workpiece dimensions are diameters of 4 - 260 mm and heights of 0.7 – 50 mm. Users of this method include manufacturers of hydraulic and injection components, roller bearings, sintered and cast components and the tooling industry or fittings manufacturers.

Lapping is a mechanical or manual production process for producing smooth surfaces within extremely demanding tolerances. It uses a mixture of lapping powder (aluminium oxide, silicon carbide or diamond) and water or lapping oil. Unlike fine-grinding, where the abrasive is fixed, lapping works with a free (rolling) abrasive. This means that very high-quality surface finishes can be achieved even with relatively coarse abrasives.

Material removal during lapping involves two processes which take place simultaneously: The lapping abrasive is pressed simultaneously into the lapping wheel and into the workpiece, and the surface is removed as a result of this relative motion. The abrasive grit rolls off between the lapping wheel and the workpiece surface, resulting in deformation of the grit tips and compaction of the workpiece surface.

In fine-grinding, the material is removed using a large

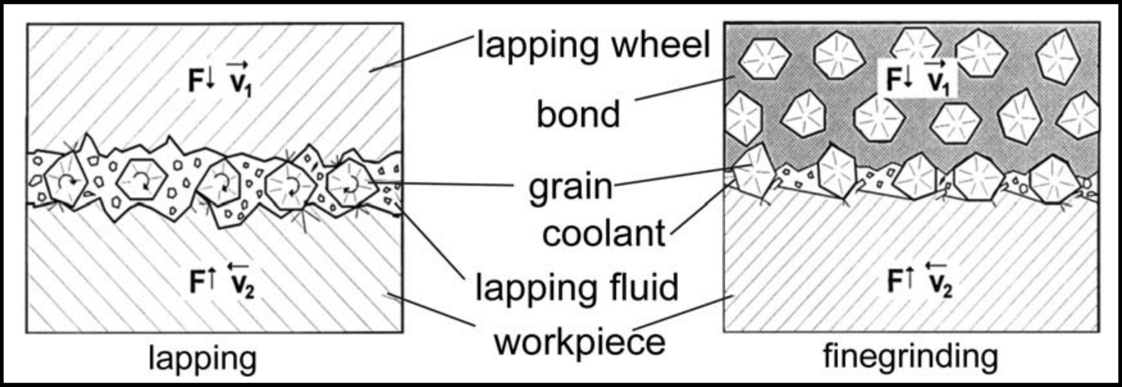


FIGURE 2: **Material Femoval Mechanisms: Lapping - Fine-Grinding**

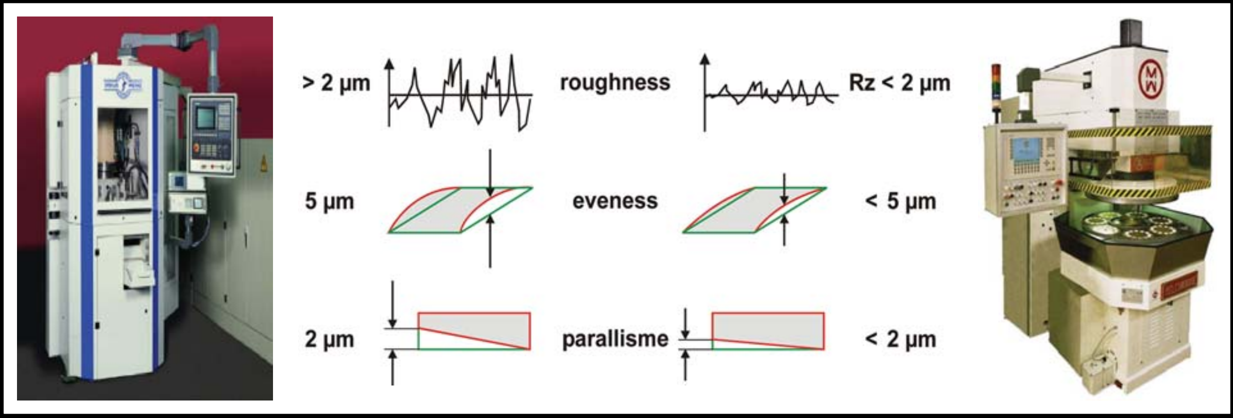


FIGURE 3: **Requirements for Surface-Grinding**

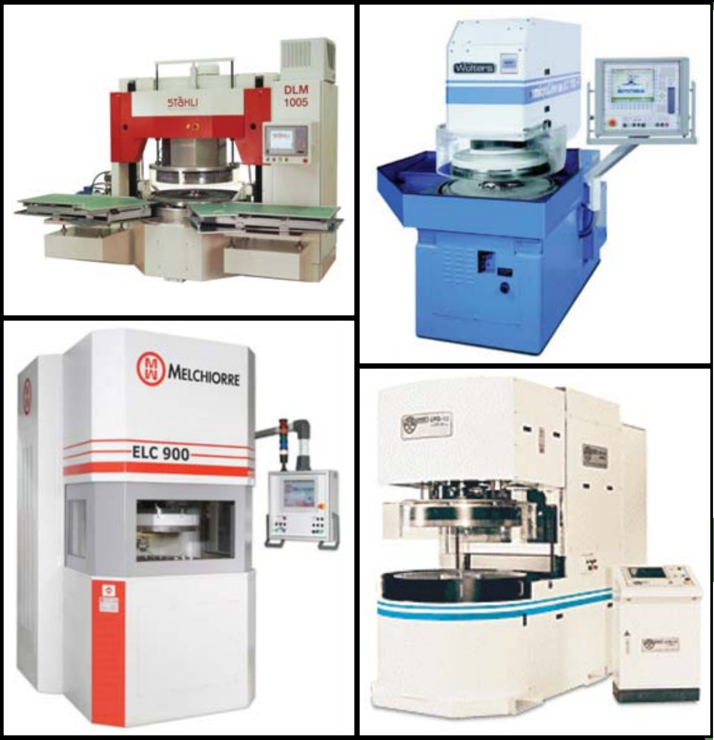


FIGURE 4: **Fine-Grinding Machines from Various Manufacturers**

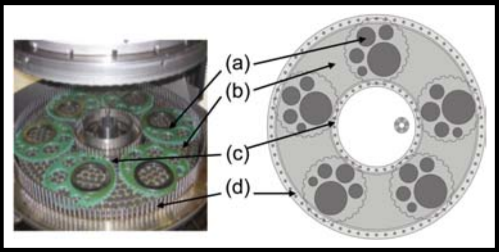


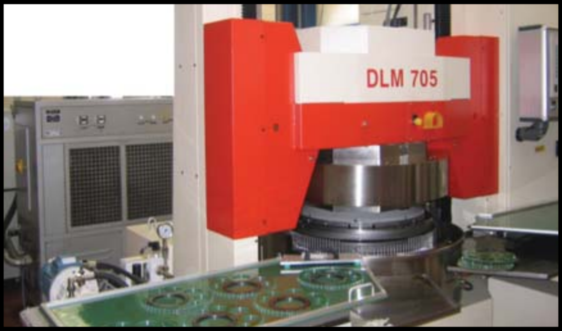
FIGURE 5: **Workpiece Guidance with Rotor Wheels in the Machine**

amount of fixed abrasive grit and at a higher speed than in lapping. The bonded abrasive grit is pressed into the workpiece surface, which generates chip formation. In addition to significantly reducing disposal costs, a cool grind is produced. Furthermore, fine-grinding leads to lower edge zone damage and lower process forces, resulting ultimately in very much higher material removal rates with surface finishes which are comparable with lapping. Another factor which should not be underestimated is the lower soiling of the workpieces which brings with it an increasing potential for process automation. Prior to fine-grinding, the workpieces are pre-ground to ensure they are plane-parallel, for example on conventional through-feed grinding machines. In the subsequent finishing or fine-grinding process, the specifications for flatness, parallelism and peak-to-valley height Rz are often significantly below 2µm (Fig. 3).

FINE-GRINDING SYSTEMS

Surface-grinding machines with lapping kinematics, also termed fine-grinding or flat-honing machines, are fitted with CBN and diamond grinding wheels for machining tough workpieces. Many machines are based on further developments of conventional twin-wheel lapping machines in a C-frame configuration, with the lapping wheels being replaced by grinding wheels.

Today further developments of such machines are in use with a stable portal design (Fig. 4, left) with high-power drives (up to P = 50 KW) per grinding wheel spindle and with significantly higher speeds (up to n = 600 min-1). These machines can be used for pre-grinding at a higher wheel speed and then, in a second step, machining to the specified dimensions at a lower speed but with identical grinding wheels. The lapping kinematics means that the workpieces describe cycloid paths while being machined. This type of relative motion between the tool



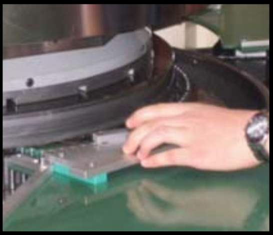


FIGURE 6: Manual Loading and Unloading Table

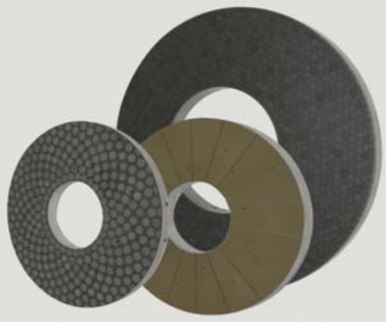


FIGURE 7: Fine-Grinding with Segmented Grinding Wheels

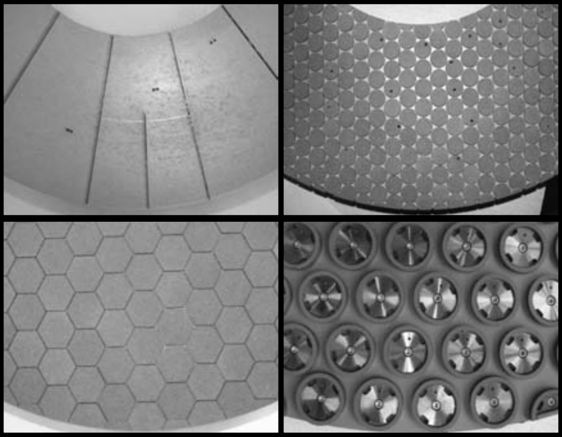
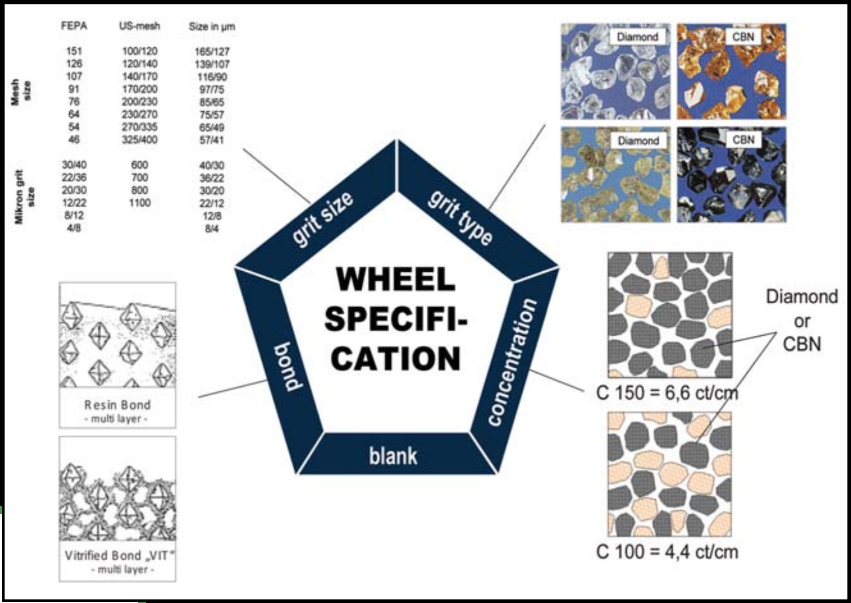


FIGURE 8: Different Grinding Wheel Layouts



	FEPA	US-mesh	Size in µm
Mesh size	151	100/120	165/127
	126	120/140	139/107
	107	140/170	116/90
	91	170/200	97/75
	76	200/230	85/65
	64	230/270	75/57
	54	270/335	65/49
	46	325/400	57/41
Mikron grit size	30/40	600	40/30
	22/36	700	36/22
	20/30	800	30/20
	12/22	1100	22/12
	8/12		12/8
	4/8		8/4

FIGURE 9: Grinding Wheel Specification

and the workpiece results in the very uniform load on the abrasive and extremely even material removal. As a result, the demanding requirements in terms of dimensional accuracy, flatness and parallelism are met with this surface-grinding method. The drive speeds for the upper and lower wheels and the inner pin ring can be regulated independently of each other and are therefore a key factor in influencing the machining result and the ability of the grinding wheels to retain their outline.

The workpieces are moved between the rotating grinding wheels (b) with the aid of carriers (a). The carriers are driven via the rotating inner pin ring (c). The outer pin ring (d) is generally fixed (Fig. 5). The complicated clamping systems which are familiar from alternative grinding methods are not required since the workpieces are placed loose in the carriers. Thanks to the flexibility of the method, a very wide range of workpiece materials and geometries can be machined. The workpieces are machined on both sides in one step by two very even surface-grinding wheels. As a result of the powered feed of the upper working wheel, the normal force required for stock removal can be maintained, irrespective of the workpiece thickness. The loading and unloading of the carriers, which is almost carried out manually, takes place directly in the machine or on loading tables which are connected to the machine (Fig. 6).

Simple, manually operated devices are used to feed the carriers plus workpieces from the table into the working space (between the grinding wheels) and then withdraw them again after machining. The grinding wheels are only opened slightly to permit this.

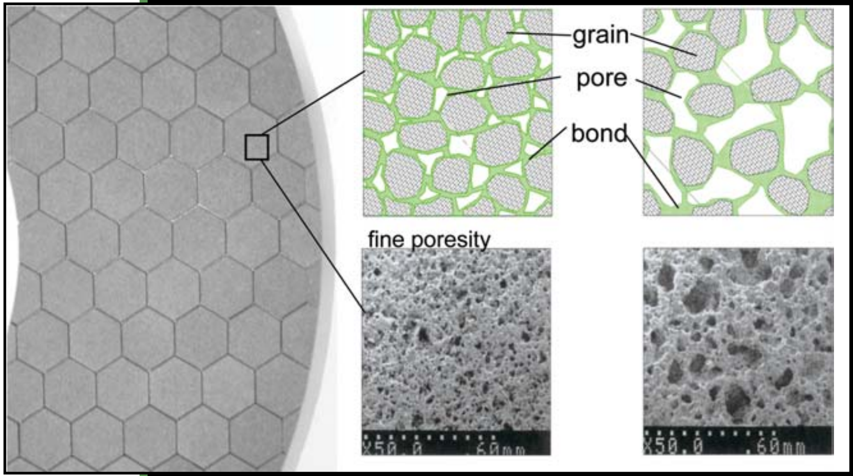


FIGURE 10: Varying Porosities in Vitrified Bonding

> *The drive speeds for the upper and lower wheels and the inner pin ring can be regulated independently of each other and are therefore a key factor in influencing the machining result and the ability of the grinding wheels to retain their outline.*

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Spring 2012	Grinding & Machining Advancements	Mar. 31, 2012
Summer 2012	CVD Diamond & cBN	May 31, 2012
Fall 2012	IMTS Issue (Machines and New Technology)	July 31, 2012
Winter 2012/2013	INTERTECH 2013 Registration Packet	Sept. 30, 2012
Spring 2013	INTERTECH 2013 Preview	Feb. 15, 2013

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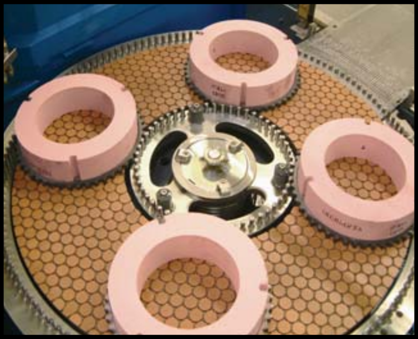


FIGURE 11: Sharpening Rings in Use – Upper Wheel Removed

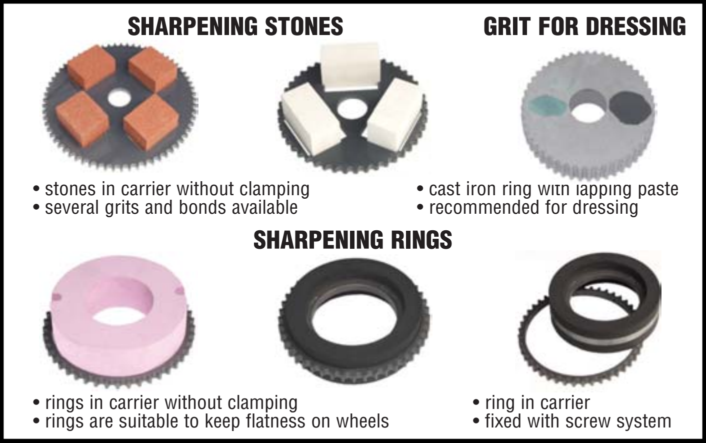

SHARPENING STONES
GRIT FOR DRESSING
• stones in carrier without clamping
• several grits and bonds available
• cast iron ring with lapping paste
• recommended for dressing
SHARPENING RINGS
• rings in carrier without clamping
• rings are suitable to keep flatness on wheels
• ring in carrier
• fixed with screw system

FIGURE 12: Different Sharpening Tools

DIAMOND AND CBN WHEELS

When it comes to double-sided surface-grinding of tough materials, the use of ceramic- and resin-bonded diamond or CBN abrasives has proved beneficial (Fig. 7). Metal-bonded wheels are also used in special cases.

These grinding wheels ensure a constant material removal rate with minimal wear. Further advantages include the lower thermal expansion of the grinding wheels, an almost non-deformable abrasive surface and low process forces. Wheels up to 1800 mm in diameter are used with a very wide variety of abrasive surfaces in the form of segments or pellets (Fig. 8). The layout of the abrasive topography is primarily influenced by the workpiece geometry, the workpiece material and the machine used.

Small workpiece diameters require small segment or pellet gaps (distances) so that the parts can be machined without becoming tilted between the grinding wheels. Larger parts, on the other hand, require modified specifications and segmentations in order to ensure the necessary specific grinding pressure. The grinding wheel specification (grit, grit size, concentration and bonding material) is adapted to take account of the workpiece and/or customer requirements (Fig. 9). Depending on the machining task, diamond and CBN abrasives in FEPA grit sizes up to 151 µm are used. Grinding wheels with microgrit sizes of 4 - 40 µm are in use where the requirement is for especially precise finishes (Rz <1 µm). Ceramic bonding materials with their user-definable porosity have an especially advantageous free abrasive effect. The pores enable or improve the transport of the chips from the contact zone and the feed of coolant.

New bonding systems allow wheel manufacturers to incorporate small or large pores in the abrasive surface, as required (Fig. 10).

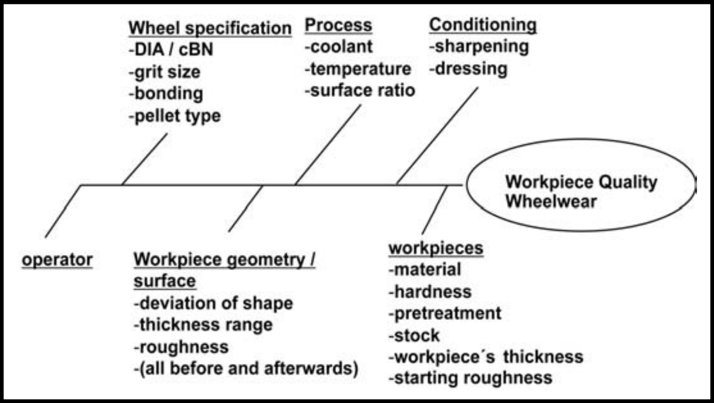
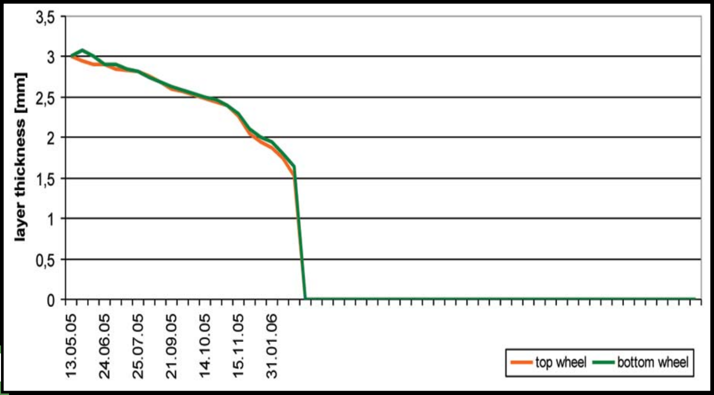
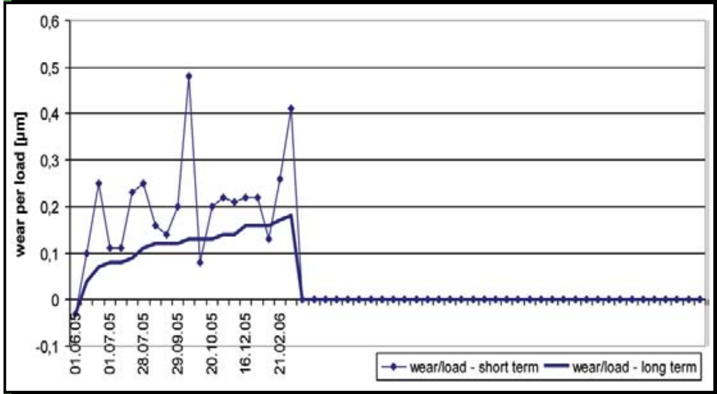


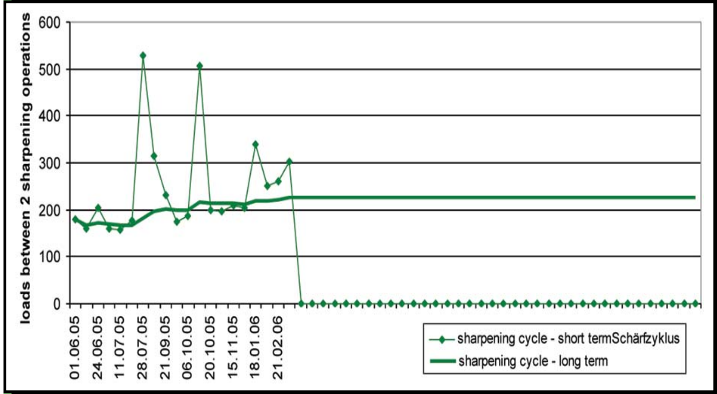
FIGURE 13: Variables Affecting Component Quality and Grinding Wheel Service Life



Layer Thickness

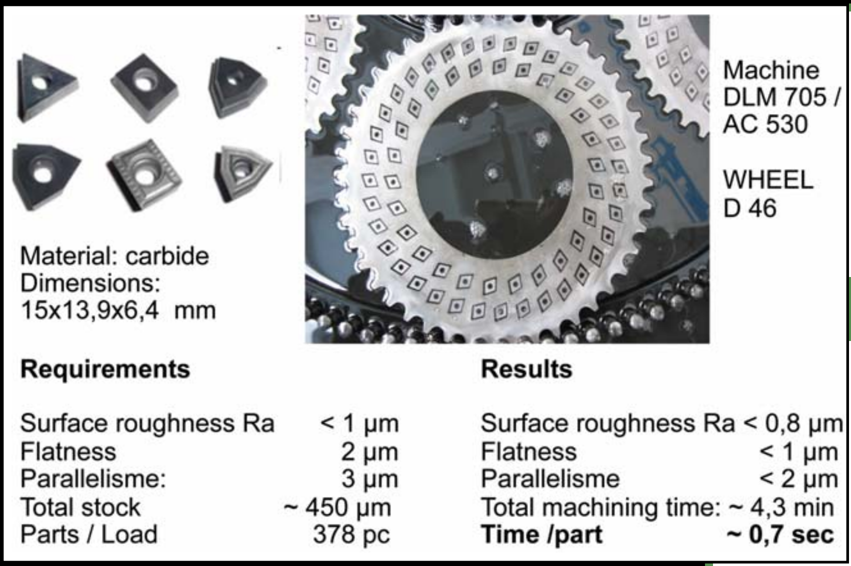


Wheel Wear Per Load



Sharpening Cycle

FIGURE 14: Documentation of Key Process Performance Indicators



Material: carbide
Dimensions:
15x13,9x6,4 mm

Machine
DLM 705 /
AC 530

WHEEL
D 46

Requirements		Results	
Surface roughness Ra	< 1 µm	Surface roughness Ra	< 0,8 µm
Flatness	2 µm	Flatness	< 1 µm
Parallelisme:	3 µm	Parallelisme	< 2 µm
Total stock	~ 450 µm	Total machining time:	~ 4,3 min
Parts / Load	378 pc	**Time /part**	**~ 0,7 sec**

FIGURE 15: Fine-Grinding of Carbide Inserts

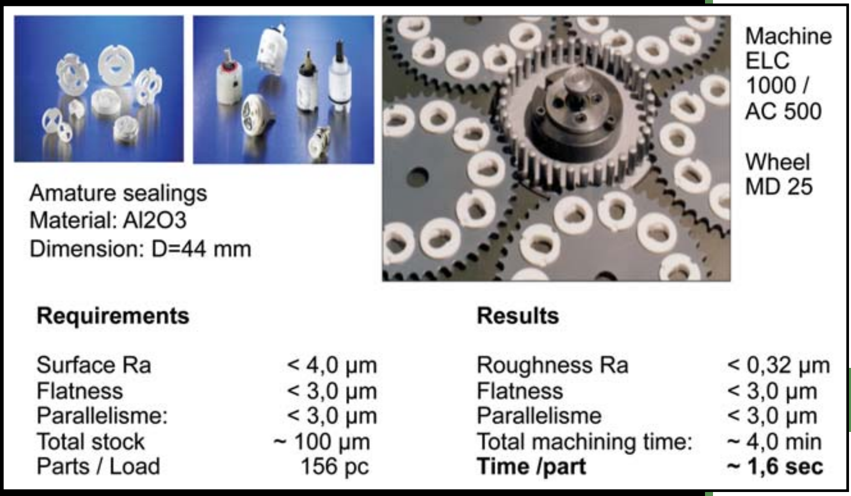
For customer applications with high material removal rates and the resulting high machine speeds, surface-grinding wheels with significantly higher drainage are manufactured in response to the required high coolant feed rate. These enable increased material removal rates of > 400 µm/min without raising the workpiece temperature.

DRESSING AND SHARPENING

Diamond and CBN grinding wheels have to be dressed or sharpened at intervals using dressing or sharpening rings (Fig. 11). Sharpening is necessary because the CBN grit becomes flattened or blunt after extended periods of use. With the help of conventional bonded abrasives the superabrasive wheel topography sometimes cracks and used grit like Diamond or CBN becomes detached.

In addition to sharpening, the use of sharpening rings in machines with diamond or CBN grinding wheels also allows the flatness of the grinding wheel surface to be corrected. This can largely replace supplementary dressing processes employed to date, such as the use of cast rings with lapping paste (Fig. 12, top right).

Compared with lapping, the use of diamond and CBN grinding wheels in conjunction with conventional sharpening rings results in a dramatic reduction in disposal costs and significantly higher material removal rates. As a result of the lower soiling of the workpieces, there is a substantial reduction in the work involved in cleaning the workpieces once grinding has finished.



Amature sealings
Material: Al2O3
Dimension: D=44 mm

Machine
ELC
1000 /
AC 500

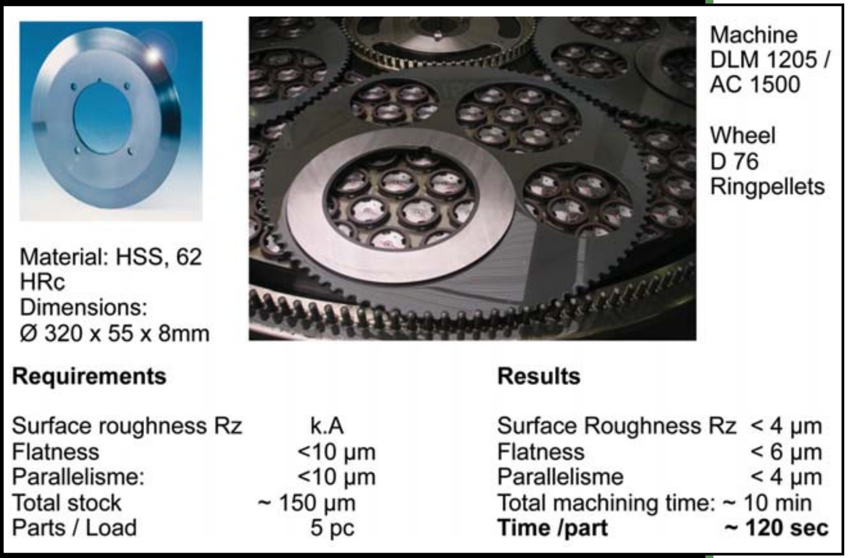
Wheel
MD 25

Requirements		Results	
Surface Ra	< 4,0 µm	Roughness Ra	< 0,32 µm
Flatness	< 3,0 µm	Flatness	< 3,0 µm
Parallelisme:	< 3,0 µm	Parallelisme	< 3,0 µm
Total stock	~ 100 µm	Total machining time:	~ 4,0 min
Parts / Load	156 pc	**Time /part**	**~ 1,6 sec**

FIGURE 16: Fine-Grinding of Sealing Discs

PROCESS CONTROL & MONITORING

Cost-effective process control during fine-grinding requires all the set points and variables to be compared. In addition to the tool and workpiece properties, it is important to consider the cooling and filtration processes when it comes to process design. A key feature when evaluating the process is the number of component runs carried out per sharpening cycle. On the machine side the process parameters can be set to such as to meet the specified surface requirements at economical material removal rates. In addition to the machine's working pressure, other process control factors include the design ratio of workpiece to tool surface area and the grinding wheel and rotor wheel speeds with the corresponding rotational directions.



Material: HSS, 62
HRc
Dimensions:
Ø 320 x 55 x 8mm

Machine
DLM 1205 /
AC 1500

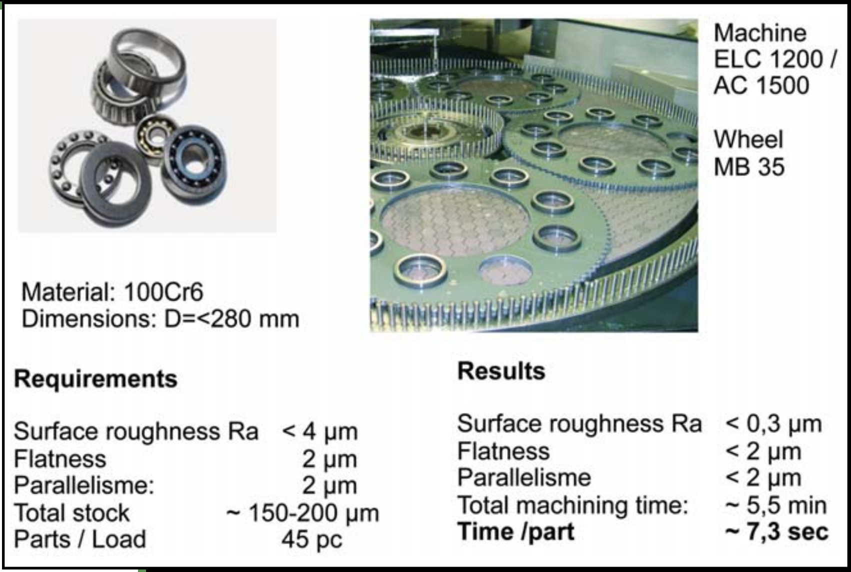
Wheel
D 76
Ringpellets

Requirements		Results	
Surface roughness Rz	k.A	Surface Roughness Rz	< 4 µm
Flatness	<10 µm	Flatness	< 6 µm
Parallelisme:	<10 µm	Parallelisme	< 4 µm
Total stock	~ 150 µm	Total machining time:	~ 10 min
Parts / Load	5 pc	**Time /part**	**~ 120 sec**

FIGURE 17: Fine-Grinding of Circular Blades

Preliminary processes prior to fine-grinding also have a major influence on the workpiece quality achieved by fine-grinding and the level of wheel wear. Changed workpiece input tolerances in terms of form faults, thickness fluctuations but also changes in material and allowances result in process modifications which can impact on the grinding wheel service life (Fig. 13). A further key factor in economical machining is the selection of the optimum process parameters. Particular importance is attached to the speeds of both grinding wheels and the inner pin ring since the speed ratio defines the shape of the path along which the workpieces move over the grinding surfaces. Path shapes in which the workpieces pass over every part of the grinding surface are the ideal. These ensure uniform tool loads and an optimum machining outcome. Disrupting factors, such as a changed coolant temperature, the loss of grinding wheel flatness, material variations and the use of incorrect sharpening rings, result in fluctuating machining conditions. The result is a loss of process capability, followed by compromised quality in the workpieces. A grinding process should therefore always be monitored and documented in real time.

Process documentation also offers economic benefits for the customer. The machining costs (wear per load) are rendered transparent, process faults and operator errors are identified promptly, and appropriate action can be taken to correct these.



Machine
ELC 1200 /
AC 1500

Wheel
MB 35

Material: 100Cr6
Dimensions: D=<280 mm

Requirements

Surface roughness Ra	< 4 µm
Flatness	2 µm
Parallelisme:	2 µm
Total stock	~ 150-200 µm
Parts / Load	45 pc

Results

Surface roughness Ra	< 0,3 µm
Flatness	< 2 µm
Parallelisme	< 2 µm
Total machining time:	~ 5,5 min
Time /part	**~ 7,3 sec**

FIGURE 18: Fine-Grinding of Roller Bearing Rings

APPLICATION EXAMPLES

The market offers a wide range of practical examples, a small selection of which is shown here. In the examples, the machining times per workpiece are highlighted, illustrating the effectiveness of fine-grinding as a process.

> *New bonding systems allow wheel manufacturers to incorporate small or large pores in the abrasive surface*

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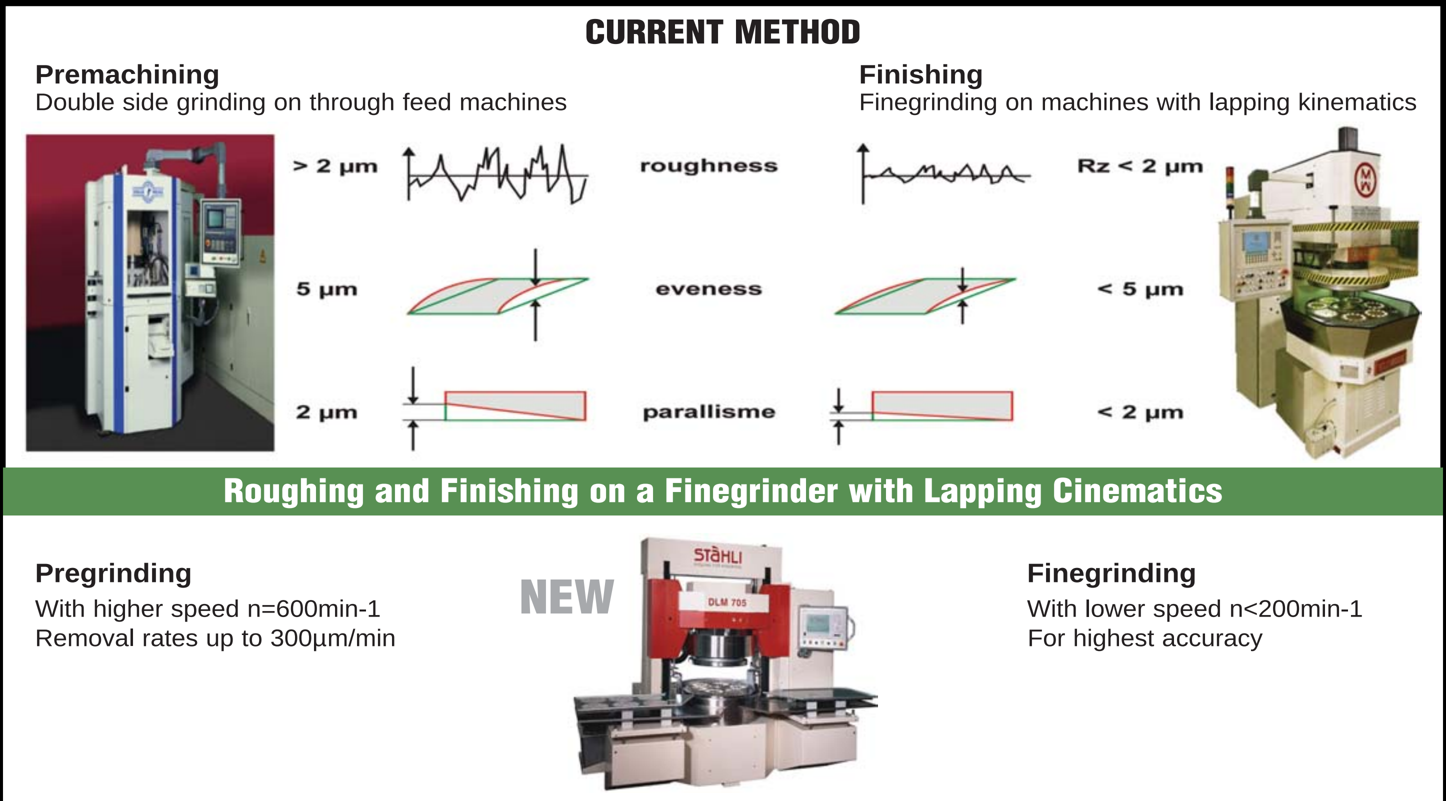
CURRENT METHOD
Premachining
Double side grinding on through feed machines
Finishing
Finegrinding on machines with lapping kinematics
> 2 µm
roughness
Rz < 2 µm
5 µm
eveness
< 5 µm
2 µm
parallisme
< 2 µm
Roughing and Finishing on a Finegrinder with Lapping Cinematics
Pregrinding
With higher speed n=600min-1
Removal rates up to 300µm/min
NEW
STÄHLI
DLM 705
Finegrinding
With lower speed n<200min-1
For highest accuracy

FIGURE 19: New Machine Concept for Surface Grinding

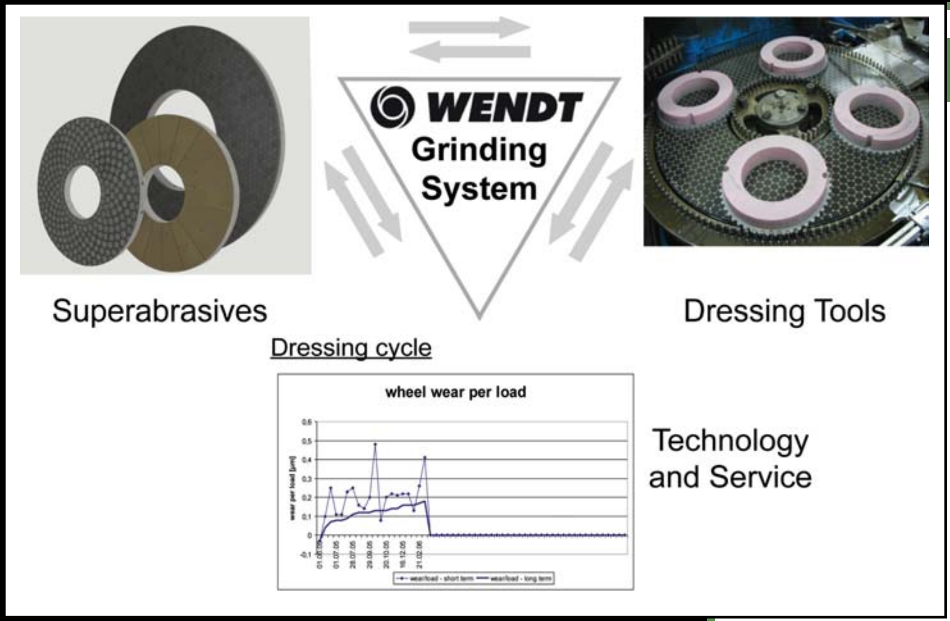

FIGURE 20: Winterthur/Wendt Grinding Systems

SUMMARY

Double-sided surface-grinding with diamond and CBN wheels is now successfully being used on machines with lapping kinematics or on finegrinding or flat-honing machines. Significant advantages over conventional lapping and grinding processes are seen. In addition to extremely precise smoothing processes with low machining rates (20-50 µm/min), this grinding process can also achieve high grinding wheel speeds and material removal rates > 300 µm/min when machining steel or >700 µm/min with ceramics (Al2O3). Rigid, variable-speed machines therefore enable roughing and smoothing with the same grinding wheels in one procedure (Fig. 19).

It is possible, by means of detailed matching of the grinding wheel specification to the component requirements, the use of effective sharpening processes and monitoring of the wheel geometry or flatness, to use fine-grinding as a reliable grinding method in place of lapping, while also achieving equally high machining rates. The complicated clamping systems which are familiar from alternative grinding methods are not required since the workpieces are placed loose in workpiece transport crates, the rotor wheels.

The use of Winterthur/Wendt grinding systems means that significantly less dressing is carried out nowadays even for highly demanding applications. New grinding wheel specifications with open bonding materials and adapted sharpening and dressing tools enable increased workpiece and load yields to be achieved with a simultaneous reduction in production costs (Fig. 20). ■

The use of Winterthur/Wendt grinding systems means that significantly less dressing is carried out nowadays even for highly demanding applications.

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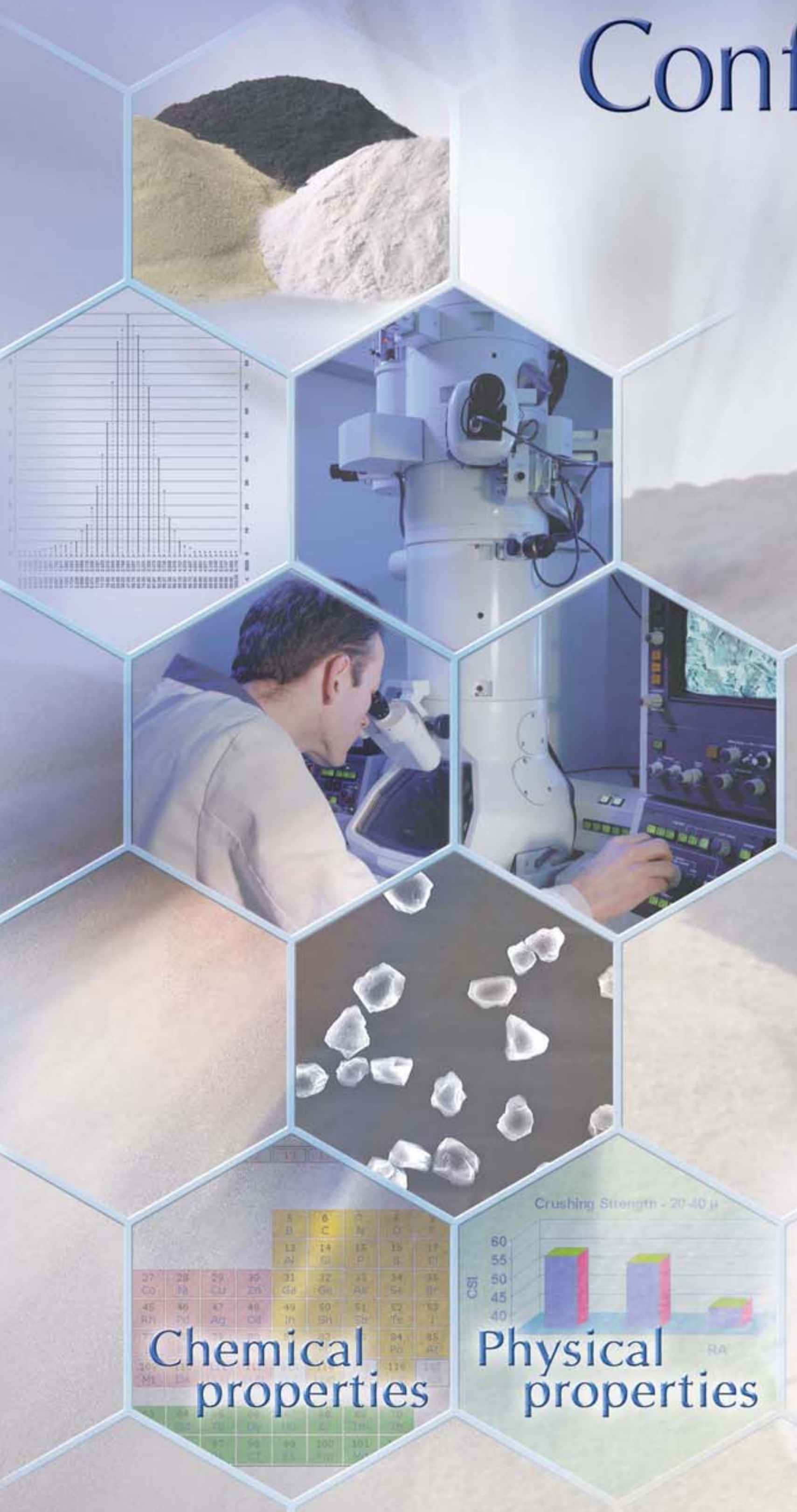

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